FOURTH SERIES, VOL. V. 1917-1922.

Annual Report and

PROCEEDINGS

OF THE

Bristol Naturalists' Society.

Edited by the Honorary Secretary.

"*Rerum cognoscere causas.*"—VIRGIL.

BRISTOL
PRINTED FOR THE SOCIETY.
MCMXXIII.

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INDEX TO VOL. V. (FOURTH SERIES).

FOURTH SERIES, VOL. V., Part I. issued (1919, for 1917.)

PRICE TWO SHILLINGS.

ANNUAL REPORT

AND

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(1919, issued for 1917).

For information concerning the Bristol Naturalists' Society generally, or concerning its meetings, please apply to the present Hon. Secretary and Editor—

MISS IDA M. ROPER,
4, WOODFIELD ROAD,
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All Books, Pamphlets, Reports of Proceedings sent by way of exchange, gift, or otherwise, and all correspondence relating thereto, should be addressed to—

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List of Members, December, 1918.

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* Has contributed Papers to the "Proceedings."

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Prof. G. A. Lebour, M.A., F.G.S. (deceased).

Prof. C. Lloyd Morgan, LL.D., F.R.S., F.G.S., 5, Kensington Place, Clifton, Bristol.

R. M. Prideaux, F.E.S., Brasted Chart, nr. Sevenoaks, Kent.

Prof. H. S. Hele Shaw, M.I.C.E., LL.D., F.R.S., 64, Victoria Street, Westminster, S.W. 1.

Prof. W. J. Sollas, M.A., LL.D., F.R.S., F.R.S.E., F.G.S., University Museum, Oxford

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William Whitaker, B.A., F.R.S., F.G.S., Freda, Camden Road, Croydon.

Prof. Sydney Young, D.Sc., F.R.S., Trinity College, Dublin.

REPORT OF COUNCIL.

To December 31*st,* 1917.

COUNCIL feels that there is no reason to regret that a programme of Meetings has been carried out during the past year, as it has afforded mental relaxation to members, and papers have been forthcoming.

The Society has unfortunately suffered heavy losses during the year by the death of nine members, and these include Dr. G. Munro Smith, President 1910-11-12 and afterwards a Vice-President, Mr. Philip Henry Vaughan, almost the last of our original members, Mr. Philip John Worsley, M.A., J.P., a member for nearly as long, and Mr. H. E. Hippisley, J.P. ; all three of them for many years our steady supporters ; Miss K. I. Williams, M.Sc. ; Mr. Upfield Green, an earnest student of geology ; Mr. Charles Isaac, a member of Council, and in the last days of the year Mr. John Tabor Kemp, M.A., our Reporting Secretary.

The total membership now stands at 114 ; 75 ordinary members and 39 Associates.

The attendance at the meetings has been steady and averaged about 30.

The following papers were given during the year :—

Feb. 1st.—" Some Subsidary Wing-Organs of Insects" ..	The President.
Nov. 1st.—" Dreams "	Mr. James Rafter, M.A.
Apr. 5th.—" Gilbert White's 'Three Willow Wrens' "	Mr. H. S. Hall, M.A.
May 3rd.—" Southern India " ..	Prof. S. H. Reynolds, Sc.D., F.G.S.
Nov. 1st.—" Local Coast Erosion and its Cure " ..	Miss I. M. Roper, F.L.S.
Dec. 6th.—" The Flea "	Mr. A. T. Davies, F.R.M.S.

In June the Annual Summer Excursion took place in the Leigh Woods, when Dr. C. Lloyd Morgan, F.R.S., ably described the ancient earthworks, and in October a successful Exhibition evening was carried out.

The two Sections of the Society, viz., Geological and Entomological, have been in active work throughout the year.

No " Proceedings " have been published this year, but those for 1915 and 1916 are now in the press to form a joint volume.

Council desires to record its thanks to Mr. Edward A. Leonard, of Clifton, for his gift of two large portfolios of New Zealand and Madeira Ferns.

It was with regret that Council heard in November that Dr. O. V. Darbishire felt obliged to give up the Honorary Secretaryship for want of time, caused by his military duties. Miss I. M. Roper took on the work to the end of the year.

Council earnestly invites the co-operation of all members in the furtherance of the study of Natural History and Geology. There is abundant need for fresh workers in every field, if the Society is to continue as beneficial to the district as it has been in the past.

IDA M. ROPER,
Acting Hon. Secretary.

The HON. TREASURER in Account with the BRISTOL NATURALISTS' SOCIETY.

GENERAL ACCOUNT FOR THE YEAR 1917.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Members' Subscriptions—				By Subscriptions to Societies—			
Ordinary	24	0	0	Ray	1	1	0
Associate	6	15	0	Commons and Footpaths	0	10	6
,, Entrance Fees	0	15	0	,, Printing	3	14	9
,, Subscriptions in advance	0	15	0	,, Fire Insurance	0	7	6
,, Arrears collected	10	0	0	,, Rent of Library and Rooms ..	8	18	6
,, Sale of Proceedings	2	14	6	,, Postages, etc.	3	11	2
,, Profit on Excursion	0	17	0	,, Gratuities	2	5	0
,, Balance forward	48	3	5	,, Balance due to Hon. Treasurer ..	1	12	0
,, Balance due to Hon. Treasurer ..	0	10	2	,, Cash in hand and Bank	72	9	8
	£94	10	1		£94	10	1

Audited and found correct,

ERNEST H. COOK,
CHARLES BARTLETT, A.C.A. } *Auditors.*

December, 1917.

LIBRARIANS' REPORT.

For the Year 1917.

DURING the past year 17 Members have borrowed books ; and the number taken out has been 89. In addition many other volumes have been consulted at the Library.

One book borrowed in 1916 has not been returned, and 12 of recent date are still in use.

Again during the year no books have been sent to the binders, and it is suggested as advisable that a fund, by special donations, should be formed forthwith, to be spent later in binding the many "Proceedings" of Scientific Societies, which are of great interest, but are not now available for study.

We have received by subscripton *British Marine Annelids*, Vol. 3, and Worsdell : *Principles of Plant Teratology*, Vol. 2 (Ray Society) ; by purchase Donisthorpe : *British Ants* ; and by exchange from the corresponding Societies 102 parts of current publications.

There has been a moderate demand for the sale of various "Proceedings" and Reprints of the Society, most of which have been supplied.

To the following donors of books we offer our sincere thanks.

Dr. SYDNEY YOUNG, F.R.S., for *Philosophical Transactions of the Royal Society*, Series B., Vol. 207 (1916).

J. W. WHITE, F.L.S., for *Journals of the Linnean Society* (Botany and Zoology), and the *Proceedings* 1913-1917.

Mons. CHARLES JANET, for Monographs on *Algae* and *Volvox*.

TRUSTEES of the BRITISH MUSEUM, for three Guide Books and six Publications of the Economic Series.

GEOLOGICAL SECTION, B.N.S., for certain parts of the *Geological Magazine*.

ENTOMOLOGICAL SECTION, B.N.S., for parts of the *Entomologist* and the *Entomologists' Monthly*.

The gift to the Society from EDWARD A. LEONARD, Esq., of two large portfolios of New Zealand and Madeira Ferns has been received, and is placed in the Library.

Six Societies belonging to enemy nations have been removed from the Exchange List.

ARTHUR B. PROWSE, LIEUT.-COL., R.A.M.C.,
Hon. Librarian.

IDA M. ROPER, F.L.S.,
Hon. Sub-Librarian.

EXCHANGE LIST.

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Belfast Naturalists' Field Club
Birmingham Natural History and Philosophical Society
Bristol Museum and Art Gallery
British Association
British Museum (Natural History), S.W.
Cardiff Naturalists' Society
Chester Natural Science Society
Cornwall, Royal Geological Society of
————, Royal Institution of
————, Royal Polytechnic Society
Cotteswold Naturalists' Field Club
Croydon Natural History and Scientific Society
Ealing Scientific and Microscopical Society
Edinburgh Geological Society
———— Royal Botanic Society
Essex Field Club
Geological Society of London
———— Survey and Museum, London
Geologists' Association
Glasgow, Geological Society of
————, Natural History Society of
———— Philosophical Society
Hertfordshire Natural History Society and Field Club
Liverpool Geological Society
———— Literary and Philosophical Society
———— Science Students' Association
Manchester Literary and Philosophical Society
———— Microscopical Society
———— Museum Library
Marlborough College Natural History Society
North Staffordshire Field Club
Norfolk and Norwich Naturalists' Society
Nottingham Naturalists' Society
Plymouth, Marine Biological Association of the United Kingdom
———— Institution, and Devon and Cornwall Natural History Society
Quekett Microscopical Club
Royal Irish Academy
Royal Microscopical Society
Rugby School Natural History Society
Torquay Natural History Society
Woolhope Natural History Field Club
Yorkshire Geological and Polytechnic Society
———— Naturalists' Union
———— Philosophical Society

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————————, Royal Society of
Queensland Museum, Brisbane
Victoria, Royal Society of

CANADA.

Canadian Institute, Toronto
Hamilton Scientific Association
Nova Scotian Institute of Natural Science (Halifax)

INDIA.

Agricultural Journal of India
Agriculture, Imperial Department of
Geological Survey of India, Calcutta

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Rennes, University of

NORWAY.

Det Kongelige Norsk Universitet Christiania

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———— National Museum, Washington
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ARGENTINE REPUBLIC.

Buenos Aires, Muses National de Historia Natural

URUGUAY.

Montevideo, Museo Nacional de

MEXICO.

Mexico, Sociedad Cientifica

GEOLOGICAL SECTION.

1917.

THE year started with 41 Members, and there were only eight meetings, with an average attendance of 17.

I have to report with regret the deaths, during this year, of two old members, Mr. Upfield Green, F.G.S., and Mr. J. T. Kemp, M.A.

At the Annual Meeting, Prof. S. H. Reynolds, Sc.D., F.G.S., was re-elected President, and B. A. Baker, F.G.S., Hon. Secretary and Treasurer for the year.

The following papers were read :—

January 18.—" National Progress in Geology ; foreign "
Prof. S. H. Reynolds, Sc.D., F.G.S.

February 16.—" Rivers " (illustrated by lantern slides)
Miss E. N. Tipson

March 15.—" Lower Coal Measures of Lancashire, and their Relations to Palaeo-Botany and Palaeo-Zoology " (illustrated by lantern slides) Miss Edith Bolton, B.Sc.

April 26.—Exhibition Meeting

May 17.—" Mountains and Hills " (illustrated by lantern slides)
Miss I. Harris

October 18.—" Elephants, Living and Fossil "
Prof. S. H. Reynolds, Sc.D., F.G.S.

November 15.—" Belemnites " J. W. Tutcher

December 20.—" Gems " (exhibition of cut specimens)
Miss M. Tuck

The Financial Report shows the year started with a balance of £1 6s. 7d. in hand. The total receipts from subscriptions amount to £3 12s. 6d., making a total to the credit of £4 19s. 1d. The expenses amount to £4 17s. 10d., which only leaves a balance of 1s. 3d. in the hands of the Hon. Treasurer, so the Society could not subscribe to the Palaeontographical Society for this year.

Seventeen subscriptions for 1917 and previous years remain unpaid.

B. A. BAKER,

Hon. Secretary and Treasurer.

ENTOMOLOGICAL SECTION.
1917

THE Section now consists of eighteen members. Seven meetings and one excursion were held during the year. There were no papers, but many rare and interesting exhibits and notes were brought forward, of which the following were the most important :—

January 19—Miss Roper, Oak Twig with swelling due to presence of *Andricus trilineatus* under the bark. Mr. G. C. Griffiths, Lepidoptera of genera *Caligo, Morpho* and *Heliconia.*

February 16—Miss Roper, Yew with clusters of leaves at end of twigs caused by the larva of the Dipteron *Oligotrophus taxi.* Mr. Griffiths, Silk Moths and South American Butterflies. Mr. C. Bartlett, Coleoptera from New Guinea, Demerara and Jamaica.

March 16—Miss Roper, Coleoptera. Mr. A. E. Hudd, specimens of *Limnobia nubeculosa, Rhyphus fenestralis,* and others ; also recorded the taking of *Dytiscus dimidiatus* at Wedmore.

April 27—Mr. A. E. Hudd, 25 species of British longicornia including *Lamia textor, Monochammus sutor, Saperda carcharis Callidium violaceum, C. variabile, C. sanguineum* and *Agapantha lineaticollis.* Miss Roper, some British coleoptera. Mr. G. C. Griffiths, *Endromis versicolor, Solenobia pomonae* and others.

May 26—Excursion to Weston Big Wood, Portishead. Thirteen species of Diurni were taken and *Heliodes arbuti.* Mr. and Mrs. C. Bartlett extended hospitality to the party.

October 26—Miss Roper, *Libellula quadrimaculata* from Black Down. Mr. G. C. Griffiths, *Papilio dardanus* in its various forms and its mimics.

November 9—Miss Roper, *Monochammus sutor* taken in Cheltenham Road. Mr. G. C. Griffiths, *Lepidoptera.*

December 21—Mrs. Sandwith, *Tipula gigantea* and others ; Mr. G. C. Griffiths, *Dasypoda hirtipes,* etc.

LIST OF MEMBERS.

G. C. GRIFFITHS, *President.*

Miss E. BOLTON	Col. T. JERMYN
H. J. CHARBONNIER	J. F. KNOWLSON
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A. E. HUDD	Mrs. SANDWITH
W. B. IVENS	Dr. W. A. SMITH

CHARLES BARTLETT,
Hon. Secretary

Account of the General and Annual Meetings.

The following accounts have been compiled by the Hon. Secretary, and the earlier Reports are based on the summaries made by the Reporting Secretary, the late Mr. J. T. Kemp, M.A., which appeared in the local Press after each meeting.

THE 54TH ANNUAL MEETING.

February 1st, 1917.

Mr. G. C. Griffiths, F.E.S., was re-elected President for the year, with minor alterations only in Council and Officers. He then delivered his first Presidential Address entitled " Some Subsidiary Wing-organs of Insects." (Printed in full in the present " Proceedings ").

THE 460TH GENERAL MEETING.

March 1st, 1917.

" Dreams," by Mr. James Rafter, M.A.

In the opinion of the lecturer dreams are intimately associated with life's activities, and he discussed at length their causes. They appear to be common amongst all nations and classes, the tendency beginning about 5 years of age, and becoming less frequent or entirely forgotten after 65 years. Dreams are probably worked out in a very short space of time, just before an awakening, and they are usually due to excitement of the brain, brought about by ill-health, by local warmth or cold, or by external stimuli on the sense organs, and as one or other of these come into play trivial details may assume great significance and turn life upside-down, and the reality remain unquestioned. Various examples and tests were instanced in support of these different causes.

Exhibit by Miss E. M. Lee, M.Sc., of male and female cones of *Araucaria imbricata* from the only known tree which bears both kinds at Bicton, Devon.

THE 461ST GENERAL MEETING.

April 5th, 1917.

" Gilbert White's ' Three Willow Wrens,' " by Mr. H. S. Hall, M.A.

Gilbert White was the first naturalist to distinguish in 1768, that three species of Wrens were to be met with in England, and he based his opinion on their varying notes. From subsequent

examination of specimens these three tiny birds, the smallest in the British Isles, had their differences set out in scientific words. The Wrens are the wood, the chiff-chaff and the willow, the two first being much alike, but each with a distinctive song, that of the willow being very pleasing. All build a domed nest, lined with hair or feathers, whilst the eggs are marked differently by red or purplish spots on a whitish ground. The clutches are usually large, and the lecturer mentioned his observations on two females of the wood wren which shared one nest. The chiff-chaff and the willow are constantly to be seen on Durdham Down during the spring and summer.

Exhibits by the President of eggs of the mourning dove, cow blackbird, and mocking bird from Florida, U.S.A.; by Miss Ida M. Roper, F.L.S., of photographs of an elm in St. Anne's Wood, Brislington, having near its top a "Witches Broom" of large size, and rarely occurring on this kind of tree; by Mr. J. W. White, F.L.S., specimens of *Ceterach officinalis*, var. *crenatum* from Blagdon.

THE 462ND GENERAL MEETING.

May 3rd, 1917.

"Southern India," by Prof. S. H. Reynolds, Sc.D., F.G.S.

The Madras Presidency, in which the lecturer had lived for two years, was known formerly by residents in Northern India as the "benighted Presidency," but proved an interesting subject. It is larger than Great Britain, and in addition to the views of temples and mosques there were shown a large number of slides to illustrate the life of the people, their religious festivals, schools, trades, groups of types of natives, the special boats for the surf, and many forms of activity.

Exhibits by Miss Ida M. Roper, F.L.S., of the edible *Morchella esculenta* from Shipham; by Miss E. M. Lee, M.Sc., of the fungus *Tulostoma mammosum* from Staunton Sands, Devon; by Dr. C. K. Rudge, of the shell of a horse mussel from the Dogger Bank, with painted scenes.

ANNUAL EXCURSION.

June 9th, 1917.

The summer excursion was made to Leigh Woods, where a numerous party of members was joined by Prof. C. Lloyd Morgan, F.R.S., who gave a clear account of the ancient camps. Other items of interest to Naturalists were also discussed.

THE 463RD GENERAL MEETING.

October 4th, 1917.

Exhibits of Natural History by the Members.

The President, Mr. G. C. Griffiths, F.E.S., collection of harmful butterflies and moths, including *Pieris* sp., *Papilio Turnus, Samia cecropia, Tropasa luna,* etc.

Miss Ida M. Roper, F.L.S., living specimen and lantern slide of *Nitella mucronata,* var. *gracillima,* Groves and Bullock-Webster, a new variety lately discovered growing in a pond near Bristol, the species being known only in six English counties.

Mrs. Sandwith, *Stachys germanica,* from waste ground near Bristol, not hitherto noted in the district ; *Hypericum linariifolium,* from Cornwall, and purple and brown hair streak from Devonshire.

Mr. A. E. Hudd, F.S.A., a case of Diptera of the family *Syrphidae* taken by him locally.

Dr. O. V. Darbishire, old botanical books, including Gerard's "Historie of Plants" (1597), Parkinson's "Paradisus," and "Theatrum Botanicum" (1640), and the "Anatomy of Plants," by Nehemiah Grew (1680).

THE 464TH GENERAL MEETING.

November 1st, 1917.

"Local Coast Erosion and its Cure," by Miss Ida M. Roper, F.L.S. (Printed in full on page 46).

Exhibit by Mr. J. W. White, F.L.S., of six water-colour drawings of local wild flowers painted by Miss F. Cundall, a former member.

THE 465TH GENERAL MEETING.

"The Flea," by Mr. A. T. Davies, F.R.M.S.

Most people do not care to dwell on the charms of the flea, but the lecturer made clear how interesting its study may be by a description of the various species of the total forty-six kinds known to be British, some being of beautiful structure, as shown on the

lantern screen. Each species lives on a particular host, and is not irritating to others, except the rat flea, whilst all possess mandibles of a spike-like form, and antennae that can be erected at will or depressed into a groove. The life history begins with eggs that are hatched in a couple of days, when the larvae move about by means of hairs, and in a fortnight turn into the perfect insect ready for a meal of blood.

Exhibits by Mr. H. J. Gibbons, of *Papilio bianor*, a butterfly of China and Japan, captured at Darlstone Head, Dorset, by a schoolboy, probably an escape from a breeding house; and *Colias Helice,* the white form of the Clouded Yellow butterfly; by Miss Ida M. Roper, F.L.S., of *Potamogeton upsaliensis,* a sub-species of pondweed new to the British Isles gathered by her recently in Dorset.

GEORGE MUNRO SMITH, M.R.C.S.

(By permission of the "Bristol Medico-Chirurgical Journal.")

In Memoriam.

George Munro Smith, M.D. (Bris.), L.R.C.P., M.R.C.S. (Lond.).

IT is with deep regret that we have to record the death of George Munro Smith, one of our most active and esteemed members.

Born in 1856, he died on January 13th, 1917, at the comparatively early age of 60, in the prime of life, and with many possible years of useful activity before him. The son of a medical man, he chose his own medical career, and living in Clifton he naturally was educated at the Clifton College. Much of his future success was doubtless due to this early training, and his teachers there would have encouraged the indications they found that he was a born naturalist, and a painstaking worker in many other fields of activity.

Afterwards he joined the Bristol Medical School, and there soon showed his interest in the profession of his choice; he won the Clarke Scholarship and was prize-man in various subjects. He was Demonstrator in Physiology from 1885 to 1887. He then decided to attend a course of Physiology at the University College, London, where the work of Sir Burden Sanderson, and Drs. Klein and Foster, was attracting much notice. He was appointed Lecturer in Physiology to the Bristol Medical School from 1887 to 1893, when he became Professor of Physiology at University College, Bristol, from 1893 to 1899. He was always associated with the work of Bristol Royal Infirmary. From 1889 to 1897 he was Assistant Surgeon, and became full Surgeon in 1897, which office he held until 1909, when he was appointed Consulting Surgeon.

He was held in much esteem by his colleagues and medical friends, and his work was much valued by the students with whom he was so much in contact, and he had the power of winning the affection and confidence of these young men. His personality was great, his sympathies were wide and various; he was a good lecturer, clear in his demonstrations, keen in the service of science.

He wrote many papers, several being published in the "Journal of the Bristol Medico-Chirurgical Society." Two of these are of especial note, the "Vis Medicatrix Naturæ,"

Presidential Address of the Annual Meeting of the Bath and Bristol Branch of the British Medical Association, and the other was entitled "The Medical Life," an address given at the opening of the 29th session of the Bristol Medico-Chirurgical Society.

Latterly, much of his time was taken up with work for the Army, as one of the officers of the 2nd Southern General Hospital. He was called up at the commencement of the War, and the great addition to his work, entailed by the office of Lieut.-Col., R.A.M.C. necessitated daily attendance for many hours at the Southmead War Hospital.

George Munro Smith was elected a member of our Society in 1882, and from that time forward, a period of thirty-five years, he took the keenest interest in the work of the Society. He became a member of the Council in 1886, and was President of the Society for the years 1910, 1911 and 1912. He was a true lover of Nature, a born field naturalist, an accurate observer and careful interpreter of facts. He was especially interested in the birds of the Bristol district, more particularly our rarer summer, and winter migrants; the nesting of many of which he has recorded in this locality from time to time. He was most successful in obtaining photographs of nests built in high trees, and other inaccessible situations; and was thus able to illustrate his papers with charming lantern pictures taken from life. Many of his observations on bird life were made on the Downs, the Avon banks, and the flats and marshes, on the Severn shore. He was very regular in his attendance at the monthly meetings of the Society, often exhibiting objects of interest, and taking part in the discussions. The list of papers given in the Bibliography, shows the variety of subjects that he was interested in.

In his first Presidential Address, he mentions an extraordinary irruption of Cross-bills into England; in 1909 large flocks being general in most of the Southern Counties, several flocks occurring in this neighbourhood. In the spring of 1910 he found three nests of this bird, at King's Weston.

Munro Smith's great work "The History of the Bristol Royal Infirmary," which occupied the last few years of his life, and was published after his death, a handsome volume of some 500 pages, gives a valuable record of the foundation, and history, of one of the oldest Provincial Hospitals of this country. In a review of this book in the *Times* occurs the following sentence: "Many hospitals of late have had a life and work written of them, mostly London hospitals, but this History of Bristol Royal Infirmary beats them all. Its history is delightful, not as a romance, but as a vivid, minute, intimate, and faithful picture, of 180 years of the life of

Bristol, and pages and pages of Munro Smith's writing are as amusing as Pepys." This history will be a lasting memorial of his labour.

Munro Smith will be greatly missed at the meetings of the Bristol Naturalists' Society, where his cheery personality and ready wit were always appreciated by his fellow members.

C. K. R.

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PRESIDENTIAL ADDRESS.

By George C. Griffiths, F.E.S.

"Some Subsidiary Wing-Organs of Insects."

Although our thoughts throughout the past year have been tinged and shadowed by the Great War, our Society has on the whole had good attendances at its meetings, and they have been very instructive and enjoyable ones, at least they certainly were to your President.

We deeply regret that during last year our President from 1884 to 1887, Sir William Ramsay, has passed away. This great chemist, so well known for his researches on Argon and Helium, was for some years Principal of our University College, and was the author of several valuable papers read before this Society. Death has also called away Prof. Sylvanus P. Thompson, who contributed several papers to our "Proceedings," and also four other members, including a late President, Dr. G. Munro Smith.

Some 25 years since my attention was drawn to the study of the Frenulum, that remarkable organ which unites the fore and hind wings of some of the Lepidoptera during flight, and it is the subject with which I propose to deal to-night. In 1914 I was invited to exhibit in Germany a model or photographs of this organ, and I would point out the splendid state of preparedness and organisation, which did not even allow a paper read before the Entomological Society of London in 1897 by so obscure and unknown a worker as myself to be overlooked by the Germans.

The whole subject of the Flight of Insects is a most fascinating one, though on account of the small size of the creatures and the extreme rapidity with which the wings are moved, it is surrounded with difficulty.

Thanks to the vast improvement in modern photography, much has been done by various patient and painstaking observers, in the forefront of whom may be named the distinguished French Scientist, Marey, who has calculated the number of wing-beats per second of certain common insects, but it seems probable that owing to friction many examples were retarded in speed. Some of his results are as follows :—

	Wing-beats per second.
Common Fly	330
Drone Fly	240
Bee	190
Wasp	110
Humming Bird Hawk Moth	72
Dragon Fly	28
White Butterfly	9

Prof. Robert Von Lendenfeld, of Prague, also published in 1903 some remarkable instantaneous photographs, and was good enough to send me unasked a copy of his paper. One of the photos shows a series of clear representations of 10 to 15 phases of one wing-beat of *Calliphora vomitoria* (the blue bottle), some of these being secured by an exposure of 1-42,000th of a second, and taken at intervals of 1-2,130th of a second.

But I wish to-night to call your attention to some varying ways, or artifices if I may call them so, by which the characteristic flight of certain insects has been brought about. First of all we find that the thorax of an insect consists of three rings, each of which carries a pair of legs, and the second and third rings usually each carry a pair of wings. The muscles moving these wings are described by Prof. Ainsworth Davis in his work, "The Natural History of Animals." He says, "The thickened portion of the wing may be regarded as a lever, of which the fulcrum is situated in the wing-joint. To the short arm of the lever, internal to this, a muscle is attached, by which the wing is raised. The downward stroke is effected by a more powerful muscle, which is attached to the wing a little way outside the fulcrum. Other muscles which are not attached directly to the wings, but alter the shape of the thorax, help to bring about the upward and downward movements. This region of the body is flattened by vertical muscles during the contraction of which the wings rise. There are also longitudinal muscles by the action of which the thorax is shortened and the wings lowered."

In the Dragon Flies, possessed of an exceedingly powerful flight, we find that the hind wings are as large, or in some cases even larger than the fore-wings. The two pairs of wings appear to be capable of independent action or of being used in conjunction, and consequently the muscular arrangements are very complicated. In addition to elevator and depressor muscles there are others, by means of which the wings can be rotated and adjusted. Those of us who have captured or tried to capture dragon flies, must have noticed the adroit and instantaneous way in which they steer their flight to avoid a butterfly net, sometimes over it, or under it, sometimes by a rapid turn, which is most difficult to follow, this remarkable flight stamps them as the long-winged falcons of the Insect World, and enables them to overtake their prey by swoop or gyration too swift for the eye to follow. Well may one of the fastest French aeroplanes bear the title of Demoiselle, the name by which these beautiful insects are known in France—a more poetical name truly this, or its German equivalent "Wasserjungfer," than our countryside appellation of "Horse Stinger," or the American titles of "Devil's Needles" or "Snake Doctors," the latter referring to the superstition among the Southern negroes that they bring dead snakes to life.

But if the exigencies of its hawk-like flight have developed the Dragon fly's wings in one direction, namely, independent action, the varied conditions of flight in other orders have brought about certain contrivances to cause the two wings of each side to act together, at least during the down-stroke.

In the Hymenoptera the fore and hind wings are united by a row of hooks on the front margin of the hind wing, which lock into a fold in the hind margin of the fore-wing. These hooks are called hamuli, and may be clearly seen with the microscope, in both the bee and the wasp. They are also to be found in the other insects of the order, with the exception of some minute species. Newport says the hooks are arranged "in a slightly-twisted or spiral direction along the margin of the wing, so as to resemble a screw, and when the wings are extended attach themselves to a little fold on the posterior margin of the anterior wing, along which they play very freely when the wings are in motion, slipping to and fro like the rings on the rod of a window-curtain."

Among the Trichoptera or Caddis-flies, the leathery-winged insects so familiar to us in the neighbourhood of rivers and streams, we find the fore and hind-wings of many species united by means of a jugum, or yoke. This is a small lobe extending from the base of the fore-wing under the costal or front margin of the hind-wing. We may illustrate this by *Rhyacophila dorsalis.* The organ is evidently a primitive one, and we meet it again in two archaic groups of the Lepidoptera, to which the Trichoptera are certainly closely allied. These are the Micropterygidae, small moths resembling the Tineids in appearance, and the Hepialidae or Ghost swifts, some of which in Australia attain to a very great size. A female specimen of *Zelotypia stacyi* in my collection is 8¾ inches in expanse of wings, whilst a male of the same species measures 7½ inches. Other Australian species belonging to the same group expand to 5 or 5½ inches in the female sex. We may illustrate the jugum in these two families of the Lepidoptera by the small *Micropteryx purpurella,* and one of our British Ghost-swifts, *Hepialus humuli.* The flight of these Swift-moths is very rapid, but at the same time peculiar; the male of *H. humuli,* the common Ghost-moth, is often seen swinging to and fro in the air with an almost pendulum-like motion, whilst the female, with whom in that species selection seems to rest, makes a sudden dart into the assemblage of swinging males and strikes down the mate which she has chosen.

But the jugum, whilst perhaps suitable for the singular mode of flight of the Ghost-moth, would be quite inadequate to the strong, straight-forward motion of many moths, such as the Sphingidae or Hawk Moths, some of which on occasion cover leagues of land and sea when the furor of migration impels them. We, there-

fore, find in the majority of the Heterocerous Lepidoptera another and more complicated organ, the frenulum, which we shall have to consider more in detail. But first we must just mention that certain of the great Bombycine Moths and all the Butterflies, with the exception of one very singular species, *Euschemon rafflesia*, have no frenulum or jugum, but the necessary connection of fore and hind wings is brought about by the pronounced shoulder of the fore edge of the hind-wing, which extends under the fore wing almost to the costa, and so causes the down-stroke of our broad surface of wing-area. This may be seen in *Telea polyphemus*, one of the largest North American Bombyces. We may observe, however, that *Bombyx mori*, the well-known Silkworm moth, although possessing this shoulder to the hind wing, has yet a very small rudimentary frenulum-spina, as also have the two remarkable North American Moths, *Cicinnus melsheimerii* and *Lacosoma chiridota*, called by Comstock the sack-bearing frenulum-losers. That author says that the presence of this rudiment first suggested to him that those families of the Lepidoptera, termed by him "frenulum-losers," were descended from frenulum-bearing ancestors.

The beautiful group of the Uraniidae, so difficult to assign to a satisfactory position in classification, also have a similar development in the humeral portion of the hind wings and the frenulum is absent so far as the genus *Urania* is concerned. As regards other Uraniid genera, *Nyctalemon* has in some few instances a very imperfect rudiment, but *Sematura* possesses a frenulum, though so feebly developed as to be of little use. *Coronis* on the other hand in the thirteen species examined by me has a frenulum which, though rather slender in both sexes, is probably sufficiently strong to be effective.

Passing on to consider the frenulum in those genera of Lepidoptera which possess it, as I have fully gone into the bibliography of the subject in my paper already referred to, I will not weary you with the various references to it in Entomological literature, but simply say that the first mention of it was in a volume published by the Swedish naturalist, De Geer, in 1752. He found the appliance only in the male, however. On the 2nd June, 1789, a paper entitled an "Account of a Singular conformation in the Wings of Some Species of Moths," by Esprit Giorna, of Turin, was read before the Linnean Society of London and published in its "Transactions," I., p. 135. Giorna was unaware of De Geer's mention of the frenulum, and lays claim to the discovery of the organ. To this he is in fact partially entitled, as he calls attention to the similar but differentiated apparatus found in the females of many species, which had not previously been recorded.

We may now deal shortly with the comparative development of the organ in the various groups. And first we find the highest perfection of the frenulum in the Sphingidae, or Hawk Moths, the

spina of the male attaining to maximum size and strength, and the retinaculum being powerful and capable of holding with a firm grip. The spinulae of the female too are strong, and their extremities converge to a fine point, thus forming a claw or hook, which catches the bunch of scales on the median vein of the forewing with considerable effect. These characters hold good with the great majority of the species, but some members of the sub-family Amorphinae form a noteworthy exception. Of one of these, *A. populi*, Giorna states that it is without the frenulum. Such however is hardly the case; the male possesses in the position occupied by the spina in other species, a process standing out from the margin of the wing, rounded in outline, and in some few examples which I have examined, terminated in a minute point. The female has a much more largely developed apparatus, a perfectly formed group of spinulae, which however are too small to be of any functional use. It will be evident on consideration that the peculiar rest attitude of *A. populi* would be quite impossible in a species with fully developed frenulum, inasmuch as the humeral angle of the hind-wing always projects beyond the costal margin of the fore-wing, and it would be necessary for the moth to withdraw the bristle from its loop every time it composed its wings for rest. I feel strongly convinced that *A. populi* had once a functional frenulum, but since the species has adopted its protective rest position, in which it resembles a bunch of leaves, it has lost the appliance except as a rudiment.

A similar rudimentary state of development also occurs in other allied species. We may specially instance the fine Australian moth, *Caequosa triangularis*, which has the spina very short and probably quite useless. Some other of the Smerinthine group such as the genus Minas of Hubner, which includes our *tiliae* (live hawk-moth) and the Continental *M. quercus* have the organ fairly developed.

The very fine and remarkable South African Moth, *Lophostethus dumolini*, usually placed in this sub-family, has the appliance in both sexes. The flight of many Smerinthinae is so different from that of the typical Sphingidae, and their habits are so much more sluggish, that it is interesting to note the diversity in the apparatus. In such powerful fliers as *S. convolvuli* and some of the American Sphinxes, the strong yet elastic grip of the spina and the wire-like retinaculum must have the effect of bending over the costal edge of the fore-wing just in the same way that the carefully calculated curve or "camber" of the upper fore edge of the aeroplane gives stability to the machine in its flight.

The Agaristidae and Arctiidae have the organ strongly and fully developed, the retinaculum in many of the latter being of very unusual length, as may be seen in Arctia sp ?, Florida.

Nearly all the species of the great family Noctuidae have the frenulum normally developed, but of the Indian genus *Stictoptera*, Hampson writes : " Frenulum of male very strong ; single in female." This single spina of the female is very interesting, as being at variance with all the nearly related genera.

In the Geometrida the frenulum is found in most of the genera, but, as may be expected from the frail and slender structure of their wings and bodies, we find it of weaker development than in the stronger-bodied Noctuidae. In the genera Pseudoterpna, Geometra and Phorodesma, the humeral angle of whose hind wings is much produced forward we find in the male a very weak spina, whilst in the female the spinulae are either nearly rudimentary or altogether wanting. In Iodis the frenulum is absent in both sexes. In one section of the genus Synegia as defined by Hampson in his book, " The Moths of India," the retinaculum is a tuft of hair, in a second it forms a large spatulate plate, whilst in a third it is described as bar-shaped. The same author names some genera of Indian geometers—*Genusia, Hupulia,* part of *Naxo, Eucrostis, Paramaxates* and *Thalera* as being without the organ.

Prof. Comstock (" Study of Insects," p. 260) writes of the Sesiidae—" Another remarkable feature of the forms that we have studied is that in the female the bristles composing the frenulum are consolidated as in the male." Among our British Sesias this holds good in respect of *S. ichneumoniformis* and *S. cynipiformis*, but *S. myopaeformis* and *S. tipuliformis* have the spina single for almost one-third of its length and bifid at the tip. The last named species also occurs in North America, and this peculiarity has apparently been overlooked by Comstock, and this is not surprising, as the spina under microscopic examination appears at first sight to be single and its divided nature is only revealed under slight pressure. The spina of the female rests under a catch composed of scales proceeding from the costal nervure of the fore-wing, which bends over very strongly, thus differing from the normal development in the female sex, in which such scales are placed on the median nervure.

The Tortricina and most of the Pyralidina have the frenulum of the usual character, but it is in some of the members of the latter group that the most singular variations of the organ are found. Hitherto we have found that the spina of the male insect works through a retinaculum arising from the costal nervure of the fore-wing, but in several species of the British Pyralides the male spina locks into a fasciculus of strong scales on the median nervure, in fact in the manner generally characteristic of the organ in the female. Amongst these are *Agrotera nemoralis, Endotricha flammealis, Diasemia literalis, Stenia punctalis, Botys flavalis, B.*

fuscalis, *B. verticalis*, and *B. asinalis*. In each of these species the female insect has two spinalae, but in *Cataclysta lemnalis*, which has the male frenulum as above described, the female has a single spina exactly similar to that of the male. In the Phycitinae, according to Ragonot and Hampson the spina of the frenulum is single in the female, as in the male. Both these authors refer to a striking peculiarity of the *Chrysauginae*. In many species the spina of the male is described as being much thickened, flattened and contorted, and in some instances accompanied by a strong lower fork. This very singular development appears not to have a parallel in any other group. Hampson ("Moths of India," IV., p. 371) refers to certain species of *Crocidolomia* as having a thick tuft of hair springing from the sub-costal nervure, whilst from a fringe below the median nervure arise four strong curved spines playing on the sub-costal tuft. At first sight these processes appear to be ancillary to the frenulum, but after a careful examination of several specimens from Queensland I have come to the conclusion that this is not the case. No binding of the wings can be due to these spines, as both they and the tuft of hair belong to the fore-wing only, whilst the supposition that they hold down the point of the spina after passing through the retinaculum is negatived by the fact that they are at too great a distance from the base of the wing to come into contact with it.

Turning to the great group of the Tineina we find in the Psychidae the frenulum of the male is usually weak and slender, in all the genera except Narycia and Diplodoma the females are wingless, and examination therefore only applies to the male. My researches in these were carried out at the instance of Mr. Tutt, for his book on "British Moths," and as neither his collection nor my own contained certain very rare species, he borrowed a number of specimens, including one or two practically unique, for my examination. I can only say that I made this in fear and trembling, lest any accident should happen to these valued insects, and it was with feelings of relief that I packed them up and returned them to the lender.

A much more detailed and elaborate examination was made for Mr. Tutt's book, in another group, the Alucitids or Plume moths, and this was productive of some interesting results. At Mr. Tutt's suggestion, a comparative measurement of the length and diameter of the spina was undertaken, and these dimensions were found to vary very much in the several species. The greatest length of those measured was 1-16th of an inch in *O. lithodactyla*, and the smallest, in *B. paludum* 1-40th of an inch, whilst the diameter varied from 1-425th of an inch in *P. isodactyla* to 1-1,130th of an inch in *B. paludum*, but it must be borne in mind that individual variation in size might occur to modify these figures. Many specimens, of 38 British and allied European forms, were dealt with, and I was

surprised to discover that, of these, 25 species possessed in the female imago a *single* spina, which of course in normal Lepidoptera is characteristic of the male, whilst in the remaining 13 species, the female spina is *double*. More than this, when my tabulated statement was sent to Tutt, he found that my grouping of the species exactly coincided with his own table of genera, arrived at from an independent consideration of the other specific characters. That is to say, my "single spina" group included all his Platyptiliids, and my "double spina" group all his Abucitids. Referring to this, Tutt remarks ("British Moths, Vol. 5, p. 118): "This is a marvellous result, because it gives us a dichotomous division of the superfamily agreeing with our Platyptiliinae and Alucitinae, the Agdistids in this respect suggesting a branch of the former." This concludes a cursory glance at the development of this singular organ in the various Lepidopterous groups, but I still feel that much more remains to be done in its study, particularly amongst the exotic Pyralidae, which will certainly repay the student.

I cannot close without expressing my appreciation of the kind help and encouragement received on many occasions from Prof. Poulton, Mr. William White, the late Mr. J. W. Tutt, and for the facilities which have been given me by Mr. H. Bolton and the Museum and Art Gallery Committee for the examination of Lepidoptera in the Bristol Museum collections.

Lower Coal Measures in Relation to Fossil Plants and Animals.

By EDITH BOLTON, B.Sc.

Read before the Geological Section, March 15th, 1917.

STRATIGRAPHY OF LOWER COAL MEASURES OF LANCASHIRE.

ALMOST the whole of our knowledge of the palæozoic plants has been derived from careful study of the plant remains found in the Bullion Mine of the Lower Coal Measures of Lancashire. This mine, together with its continuation into Yorkshire, as the Halifax Hard Bed, is unquestionably the most interesting, and from a purely scientific point of view, the most valuable coal seam in the world. It has yielded more botanical treasures than all the other coal seams in the world put together. In no other place are plant remains found in such an excellent state of preservation.

The coal seam of the Bullion Mine with its associated flora and fauna has not yet been fully considered, and I propose therefore to give a general outline of the main facts relating to it. The position of this mine will be best understood by the following list of the seams known to occur in the Lancashire Lower Coal Measures :

		ft.	ins.
Upper Mountain or Forty Yards or Half-Yard Mine*		1	6
Two-Inch Coal			2
Bullion or Upper Foot Mine, 8ins.	Five Feet or		
Gannister Mine, 2ft. 6ins. ..	Union Mine ..	5	0
Lower Foot Mine			10
Bassey or Salts Mine		2	6
Coal (Ten-inch)			10

To say that the Bullion Seam is the uppermost but one of the Lower Coal Measure seams is not wholly correct, nor is it wholly correct to say that the seam in which the coal balls with plant remains occur is the Bullion or Gannister seam. This is often done, however, and requires some explanation. Over a considerable area the Gannister and Bullion seams are separated by some 46 ft. of rock, but along a line running north-west and south-east between Burnley and Rossendale the two unite and form a single seam. In the area where these seams are separated, the Gannister seam has a thickness of 2ft. 8ins., the Bullion Seam being only 8ins. At the point of union they well out to a thickness of 7ft. to 8ft., and afterwards maintain a thickness of nearly 5ft.

* In North-east Lancashire, coal seams are usually termed " Mines."

The shales forming the roof of the Gannister coal contain a large number of flattened doubly convex nodules of hard compact limestone, usually with a thin crust of iron pyrites. Very little is known of the "8-in." Bullion seam, as it does not pay to work. There are, however, numerous exposures in gullies and cloughs, and in these it can be seen to contain those irregular nodules of matted vegetation, stems, leaves and fruit mixed with earth, to which the name "bullion-ball" or "coal-ball" has been given. The limestone nodules which occur on the roof of the seam were formerly termed "baum-pots" by the old miners, but the term appears to be no longer used.

The union of the Gannister and Bullion seams was traced many years ago for a distance of about three miles across the north-eastern end of Rossendale, and at the Sharneyford colliery the limestone nodules were found separating the two seams for a distance of 70 yards, before perfect union of the two seams took place.

The first discovery of the union of these two seams was made by Capt. J. Aitken*, who accounted for the union as follows:—He supposed that the area represented by the Gannister or Yard seam was an area of subsidence, the submersion going on until a sufficient depth beneath the water was obtained as to allow of the deposition of sufficient material to form the beds of rock overlying that mine, and separating it from the thin coal above. He goes on to say in his paper "it would further appear that the surface over which the Five-Feet Coal was then in process of formation remains stationary and undisturbed, and that the operations of nature were not in any way disturbed." This view is supported by the fact that the coal of the Five-Feet Seam or Union Seam is considerably thicker than the aggregate of the two seams while separated; thus conclusively showing that the formation of coal was in operation during the period of submergence of the Gannister Coal.

This period of rest of the surface occupied by the Five-Feet Coal must have continued until after the formation of the Higher Foot Seam, when the whole area occupied by the Gannister and Five Feet Seams respectively was submerged and the whole surface received uniformly the super-imposed shales, forming the roof of the two seams, with its embedded nodules and fossils.

At the time this theory was put forward it was called in question by many, but no other has been put forward which explains so easily and conclusively the circumstances under which a union of the two mines could be brought about.

* Aitken, Trans. Manch. Geol. Soc., Vol. XIX., p. 224.

COAL BALLS.

It is in the Union or Five-Feet seam that coal balls have been found in greatest abundance and along a line corresponding somewhat to the line of union of the two seams.

The coal balls which formed the subject of study by Binney, Williamson, Hicks, and the earlier workers upon Palæo-botany, all came from the Union Seam in the vicinity of Bacup, notably at Sharneyford and Dulesgate.

The general appearance of a coal ball, or strictly speaking a calcareous plant nodule, suggests a soft, pulpy mass of decaying vegetable debris, through which roots were able to bore their way as in a piece of peat or leafy mould. In these nodules, we find that not only has the framework of the tissues been preserved, but frequently the remains of cell contents are clearly seen. In some cases the cells of a tissue may contain in each cavity a darker coloured spot which is probably the mineralised cell nucleus. The contents of secretory cells, such as those containing gum or resin, are frequently found as black material filling up the cavity of the cell or canal.

Occasionally the plant tissues have assumed a black and somewhat ragged appearance, giving the impression of charred wood. A section of a recently burnt piece of wood resembles very closely some of the fossil twigs from the coal seam nodules. It is possible that these fossils are portions of mineralised tissues which were first burnt in a forest fire, or by lightning, and then infiltrated with a petrifying solution.

In many of the fossil plants, there are distinct traces of fungus or bacterial ravages, and occasionally the section of a piece of mineralised wood shows circular spaces or canals which have the appearance of being the work of some wood-eating animal, and small oval bodies occur in such spaces, which may be the coprolites of a xylophagous intruder.

Later workers, especially Dr. Marie Stopes and Dr. D. M. S. Watson opened up an old colliery at Shore, near Littleborough, in the Union Seam, and found enormous quantities of coal balls, throughout the whole depth of the seam. The main object of these palæobotanists was to obtain material, the study of which would help in the elucidation of the probable phylogeny of present-day plants. Very valuable evidence has been obtained from the plant remains found in these coal balls, still the fossil records remain fragmentary, and so produce many gaps in the racial history of plants, which have yet to be bridged.

FLORA OF THE LOWER COAL MEASURES OF LANCASHIRE.

The fossil plants found are for the most part excellently preserved and give evidence that they are remains of what were once vast swampy forests.

Perhaps the best known plants of the Palæozoic Floras are the genera *Lepidodendron* and *Sigillaria*, types which are often spoken of as Giant Club Mosses. Of these genera, but particularly *Lepidodendron*, the coal balls of the Bullion Mine have yielded abundant records in a condition which has made it possible to obtain fairly complete information, not only with regard to habit and external features, but also to anatomical characters of vegetative and reproductive shoots. The structure of *Lepidodendron*, however, differs too widely from that of the recent Club Mosses to justify the statement that this prominent member of the Palæozoic Flora is a direct ancestor of any living plant. Prof. Seward's suggested restoration is as follows :—" A tapering trunk rising vertically to a height of 100 ft. or more from a dichotomously branched subterranean axis of which the spreading branches, clothed with numbers of rootlets, grew in a horizontal direction, probably under water." A description by Mr. Rodway, of Lycopods on the border of a savannah in Guiana, forming a miniature forest of pine-like Lycopodiums, might, with the omission of the qualifying adjective "miniature," be applied with equal force to a grove of *Lepidodendræ*. The equal dichotomy of many of the branches gave to the tree a habit in striking contrast to that of our modern trees. Linear or oval cones, agreeing in size and form with the cones of Spruce Fir and other Conifers, or with the male flowers of *Araucaria*, terminated some of the more slender branches. Needle-like leaves varying considerably in length in different species, covered the surface of young shoots, in crowded spirals, and their decurrent bases formed an encasing cylinder continuous with the outer cortex. The fact that leaves are usually found attached only to branches of small diameter, seems to point out that *Lepidodendron*, though an evergreen, did not retain its foliage for so long a period as do some of the Conifers.

Very common amongst the broken-up vegetation, which goes to the formation of a coal ball are the roots and rootlets known as *Stigmaria*. These are characterised by a smooth or irregularly wrinkled surface bearing spirally arranged circular scars, bounded by a raised rim and containing a central pit. These scars mark the bases of long single, or occasionally forked, appendages (rootlets).

The occurrence of these rootlets radiating through the shale or sandstone affords proof that the *Stigmariæ* are often preserved in their position of growth. This fact was recognised by Steinhauer*

* Trans. Phil. Soc., America, N.S., Vol. I., 1818.

and Logan*, and has been more recently emphasised by Potonie†, as an argument in favour of the view that the beds containing such specimens are old surface beds.

In 1842, Logan drew attention to the almost complete monopolisation by *Stigmaria* of the underclays, a rock which, as a rule, occurs below a seam of coal. This fact, which has played a very conspicuous part in the perennial discussion on the origin of coal, led to the almost general recognition of the underclays as surface soils of the coal forests. In the same year Hawkshaw described certain fossil trees, the largest of which had a circumference of 15ft. at the base, discovered in the course of excavating for a railway in Lancashire, in soft shale, the tree being at right angles to the bedding. The occurrence of numbers of *Lepidodendron* cones (*Lepidostrobus*) near the roots led him to recognise the possibility of a connexion between Stigmarian roots and Lepidodendron stems.

In 1846 Binney‡, at Dukinfield, near Manchester, discovered trees of a similar character. It is now generally accepted that *Stigmaria* is anatomically related to the *Lepidodendron*, but there still appears to be some doubt as to whether it is a true root.

In many cases the isolated fossils obtained by the earlier workers and given different generic names have been shown in the light of recent research to be different portions of the same plant. As an example, let us take the genus *Calamites*. The name *Calamites* has been applied to the tapering internal cast of the stem, the roots were called *Asteromyelon*, the foliage which occurred as impressions was called *Calamocladus*, *Astrophyllites* or *Annularia* by the different discoverers. The cones also had three names—*Calamostachys*, *Microstachys* and *Palæostachys*. This diversity of names is probably accounted for by the fact that nearly all the specimens were found in different stages of preservation and in no way connected with each other. It is only of recent years that the various genera have been found so situated that there was good reason for believing them to be different parts of the same plant. The fossil *Calamites* was in all probability a gigantic tree with the appearance of a modern Horse-tail (*Equisetum*) with which it is now grouped as an ancient ancestor.

Among the plant fragments of the coal balls, Prof. Bertrand discovered in 1894 fragments of petrified leaves and twigs of a small herbaceous Lycopodiaceous plant, which he named *Miadesmia membranacea*. It affords an example of a palæozoic plant compar-

* Trans. Geol. Soc., London, Vol. VI., p. 491.
† Zeits. Deutsch. Geol. Soc., 1893.
‡ Quart. Journ. Geol. Soc., Vol. II., p. 390.

able with *Isoetes* (Quillwort) and *Selaginella* (a modern Lycopod). On the ground of its general anatomical features *Miadesmia* has been included among the extinct representatives of the *Pteridophyta*. It has, however, crossed what it is customary to regard as the boundary of *Pteridophytes* and *Phanerogams*, by possessing megasporangia with the attributes of seeds.

A very common fossil in the Coal Measures is *Sphenophyllum*, a type, however, which cannot legitimately be included in any of the existing groups of Vascular Cryptogams. Although this Palæozoic genus possesses points of contact with various living plants, it is generally admitted by palæobotanists that it constitutes a somewhat isolated type among the *Pteridophytes* of the Coal Measures. Our knowledge of the anatomy of both vegetative shoots and strobile is now fairly complete, and the facts that we possess are in favour of excluding the genus from any of the three main divisions of the *Pteridophyta* (*Lycopodiales*, *Equisetales* and *Filices*). Sections of the stem of *Sphenophyllum* are easily recognised by the solid triangular mass of xylem.

Few fossil plants are so familiar as the well preserved carbonaceous impressions of compound leaves on the Coal Measure shales which were referred by other earlier workers to recent genera and species of ferns and even accepted by many later workers as undoubted examples of Palæozoic ferns. The discovery of these pseudo-ferns recently christened *Pteridosperms* or seed-bearing fern-like plants has added enormously to our knowledge of plant evolution, and at the same time rendered more difficult the task of unravelling the past history of the true ferns. It is still true, as Prof. Tansley says, " that the biggest gap in the plant kingdom at the present time is undoubtedly that which separates the Pteridophytes from the plants definitely below them in organisation."

True fossil ferns in the Lower Coal Measures are represented by the *Cœnopteridea* which include *Botryopterea* and *Zygopteridea*, the latter can often be recognised in section by the anchor-like xylem, which is particularly well seen in *Ankyropteris*.

Binney instituted the genus *Stauropteris* for leaf petioles, which he found in the Lower Coal Measures of Oldham, Lancashire. It is characterised by a stele composed of four groups of xylem. Williamson spoke of this genus as " one of the most beautiful and also one of the most perplexing of the plants of the Coal Measures." He discussed its possible affinity with both Lycopods and ferns, deciding in favour of the latter group.

The name *Sphenopteris* is one of the many generic names instituted by Brongniart, and it is the generic designation used for a great number of Palæozoic and later fronds. The most characteris-

tic species of the Middle and Lower Coal Measures is *Sphenopteris furcata.* Some of the pinnæ found have organs which appear to be true sporangia. The plants having these organs are grouped together as a new genera called *Telangium*, the type species *T. Scotti* being based on material from coal balls from Lancashire.

One of the commonest of fern-like plants of the Coal Measures is that known as *Alethopteris.* The frond of *A. lonchitica* consists of a stout mid-rib supporting on either side a number of long narrow pinnules, which are attached by their bases. Each pinnule is marked on its dorsal surface by a deep furrow, from which minute veins pass out at right angles to the free edge. The bases of the pinnules are generally united with each other as well as with the main axis. The apex is usually very acute. Closely allied to this genus is the common tri-pinnatifid frond of *Pecopteris.*

The first expressed doubt (1883) that these fern-like plants were all ferns arose from the persistent absence of sporangia. Later the anatomy of several forms was discovered to show characters combining those of ferns and cycads, and for such forms the group name *Cycadofilices* was proposed (1899). In 1903, seeds were found on the leaves of certain *Cycadofilices* and the group name *Pteridosperms* was proposed to include the *Cycadofilices* that bear seeds. The knowledge of the existence of ferns during the Carboniferous period came to depend more upon inference than upon any sure recognition of their remains. At any rate, it seems certain that almost all of the so-called fern vegetation of the Carboniferous belonged to these primitive seed plants. Another palæozoic group of gymnosperms contemporary with the *Cycadofilices* is the group *Cordaitales*, and these two groups made up most of the seed plant vegetation of the Palæozoic, the *Cordaitales* being the dominant gymnosperm forest type. The two groups appear side by side as far back as the records go, but intergrading forms indicate that the *Cordaitales* probably arose from the *Cycadofilices* at a very early period. The *Cordaitales* were tall and slender trees probably with a dense crown of branches, and a great abundance of simple and large leaves. The general appearance of these trees differed from that of any living gymnosperm. It seems reasonable to conclude, therefore, that the *Coniferales* have been derived from the palæozoic *Cordaitales*, which also gave rise to the *Ginkoales* (the Maiden Hair tree). The *Coniferales*, however, have retained fewer primitive characters than the *Ginkoales.*

Fauna of the Lower Coal Measures of Lancashire.

The "baum-pots" are exceedingly refractory, and usually split very unevenly, so that the contained fossils, invariably in most excellent preservation, are often broken. Nevertheless, an interest-

ing group of animal remains has been discovered in them, and of forms which must have been contemporaneous in time with the plants occurring in the nodules.

The fauna of the Lower Coal Measures is comparatively poor, although most of the divisions of the invertebrate animal kingdom are represented. The *Echinoderms* are represented by the *Crinoids* or Sea Lilies, and by the early form of Sea Urchin, *Archæocidaris*. *Spirorbis pusillus* and *Arenicola carbonaria* are the only examples of the Worms, but many of the shales show peculiar markings which are believed to be worm tracks and burrows.

The *Brachiopoda* are represented by seven genera—*Lingula mytiloides* with its thin nearly equi-valved shell is fairly common, so also is *Orbiculoidea nitida*. Three species of *Productus* are known to occur, namely, *P. semireticulatus*, *P. scabriculus*, and *Chonetes hardrensis*.

Of the *Lamellibranchiata* or *Pelecypoda*, *Carbonicola* is by far the commonest ; at least five species of this genus have been recorded. This genus is very similar to *Unio*, but the anterior part of the shell is broad and tumid, and the posterior part narrow and compressed. It was in all probability a fresh-water mollusc. *Pterinopecten papyraceus* and *Posidoniella lævis* are the only other common pelecypoda.

Gasteropoda occur, but few have been named, only species of *Raphistoma*, *Euphemus*, *Bellerophon*, *Macrocheilus*, and *Aclisina* (*Loxonema*) have been described from the Lower Coal Measures of Lancashire.

At Carre Heyes near Colne, the late George Wild* discovered in close association with the Bullion seam, a bed called by him the "Soapstone Bed," in which were a great accumulation of clay ironstone. Nodules full of the shells of young *Goniatites*, Goniatites fry and the remains of a small amphibian, *Hylonomus Wildi*. More recently new forms of what are possibly *Myriapods* have been described by Dr. Henry Woodward, F.R.S.† New species of *Goniatites* and *Orthoceras* have been discovered.

Some of the smaller nodules from Carre Heyes have had all the lime washed from them by water infiltration, and are now only made up of loose earth, which can be brushed away, and the fossils liberated in perfect condition.

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* A. Smith Woodward. "On a Microsaurian (Hylonomous Wildi, sp. n.) from the Lancs. Coal-field." Geol. Mag. N.S., Decade iii., Vol. VIII., p. 211.

† Geol. Mag., N.S., Decade v., Vol. II., pp. 433-444. Oct., 1905.

Summarising our general knowledge of the Palæo-Botany and Palæo-Zoology of the Lancashire Lower Coal Measures, we may fairly assume, that the period was one in which primitive types of plant life appeared and even underwent considerable development, and that the vegetation grew upon mud and alluvial flats adjacent to a shallow sea. The animal life of the period, as contrasted with that of the Carboniferous Limestone, was a poor one, many forms disappeared and others presented a starved and stunted condition. The dominant forms were mainly Cephalopods and Fishes, whilst Gasteropods were in the main very minute and are even yet little known. The highest type of life appearing during the period is represented by the little amphibian *Hylonomus Wildi* from Carre Heyes, Colne.

Bristol Botany in 1917.

By JAS. W. WHITE, F.L.S.

THE following instalment of notes on the district flora contains a mention of the more important observations that have been reported during the year and adds several unpublished species to the local list.

Ranunculus floribundus Bab. In one of the old strontia pits (now ponds) south of Hall End, this plant bore flowers with 6, 7, 8, 9 and 10 petals—the only instance known to me of such an occurrence amongst the Water Buttercups.

R. fluitans Lam., var. *Bachii* Wirtg. From the Avon near Newton St. Loe, 1917; *Miss Roper.* No form of *R. fluitans* had previously been observed in the district. Miss Roper's plant was approved by Mr. James Groves, and by Mr. Hiern, who suggested that it might be placed under the var. *Bachii.*

["*Arabis alpina* L." *Fl. Brist.*, p. 145. Mr. Druce informs me that he finds the specimen in Herb. Watson to be labelled "Whitehall," not "White House," as written by Banks. Although this makes the locality clearer, Whitehall being a district of East Bristol, Mr. Druce thinks the plant gathered is probably *A. albida.*]

Viola lactea Sm. Discovered in June on Yate Lower Common G. and more abundantly among the heathy herbage of an enclosure at no great distance. This ericetal rarity is a welcome addition to the Bristol flora. It seems to be absent from several Western and Midland counties and to be always a local species confined to undisturbed ground on heaths and commons. There is now little doubt that the plant called *V. canina*, var. *lanceolata* (*Fl. Brist.*, p. 177) is really a hybrid—*canina* × *lactea*, as Mrs. Gregory would have been inclined to name it had *V. lactea* been known in the vicinity at the time.

Geranium phæum L. Hedgebank in Rickford Combe, Blagdon, S. *H. S. Thompson.*

[*Staphylea pinnata* L. Several tall bushes on the bank of a stream to the north of Bishop's Hill Wood, Wickwar, G., at a long distance from any garden; *Capt. Gordon.*]

[*Rhamnus Alaternus* L. A small bush amid hawthorns and brambles on Penpole Point, G.; no other introduced plants being at hand! *H. S. Thompson.* Of interest as being the second Bristol locality for this alien shrub.]

Ulex Gallii Planchon. "Aug. 26, 1836. Noticed [at St. Vincents Rocks] a *Ulex* that appears to be new. Mr. Forbes said that it exactly resembled *U. provincialis* of the south of France." *Memorials of C. C. Babington,* 57. This was written some thirteen years before the plant was described by Planchon.

Lotus tenuis W. and K. Waste ground, Cranbrook Road, Bristol; *H. S. Thompson.*

Prunus insititia L. Hedgerow between Northwick and the Old Passage, G.; *Mrs. Sandwith.* Failand Hill! Winterhead-on-Mendip; *Miss Roper.* Hillside above Clapton-in-Gordano, five or six trees; *Misses Cundall.* Several bushes bearing yellow fruit in a field hedge near Backwell, S.

Agrimonia odorata Mill. Asham Woods, S.; *R. V. Sherring.*

Potentilla argentea L. On sandstone at Longwell Green; and one plant with *Filago minima* at Mr. D. Fry's station for that species at Hanham, G.; *Miss Roper.* About a dozen plants where rock is exposed in a field below Old Down, Tockington, G.; *Id.*

[*P. norvegica* L. Plentiful on waste ground near a quarry in Kingswood parish, G., and as a weed in a garden adjoining!]

Rubus hirtifolius Muell and Wirtg. Stapleton, G.; *Rev. H. J. Riddelsdell.* Nailsea Heath and the Heath Drove, S.!

R. lasiocládos Focke, var. *angustifolius* Rogers. Durdham Down, Bristol, G. Once found by Mr. Riddelsdell in the Gully. Now conspicuous on a portion of the open Down, and in this instance less suggestive of hybridity than is often the case with plants of this aggregate.

Geum rivale × *urbanum.* In a hedge-bottom near the Blue Bowl between Chew Stoke and Compton Martin; *Miss Roper.*

Rosa arvensis Huds., var. *erronea* Rip. & Crèpin. With smooth peduncles. Path leading from Keynsham to Hanham Ferry, S., 1916; *Miss Roper.* Confirmed by Mr. W. Barclay.

Pyrus cordata Déségl. *non* Desv. *nec* Boiss. (*P. Piraster* Bor., var. *Déséglisei* Rouy & Camus). An extremely interesting discovery possibly unique in this country. On a joint excursion Mr. Bucknall was the first to notice a couple of pear trees in flower on the edge of a wood between Rangeworthy and Wickwar, West Glouc. On September 6th we found these fruiting abundantly, with a smaller one that may not have flowered. The largest tree has a girth of over four feet, and is about 40 ft. high with a spread of 30 ft. Its age may date from a period prior to the enclosure of the district in which it stands. The leaves are cordate-orbicular or slightly

oblong, obtuse or sometimes shortly apiculate, minutely crenate-serrate; the fruit globular, in size about that of a large cherry (diam. 20-25 mm.) on long erect-patent stalks. Thus the trees agree well with the characters of *Déséglisei* so far as given by Rouy and Camus.

[*Sedum sexangulare* L. Still on Wyck Rocks, 1917; *Miss Roper.* Walls near the Church at Burrington, S. 1917; *H. W. Pugsley.*]

[*Coriandrum sativum* L. G. Sparingly on a tip at Eastville! St. Philip's Marsh! *The Misses Cobbe.*—S. Among mangolds at Failand, 1917; *D. Williams.* On a tip by the Avon at Brislington! Remembering Babington's description "flowers white," I was at first puzzled by the rose-coloured petals of the Eastville plant. But Hooker and Grenier & Godron inform us that the flowers may be pink or *rougeâtres.* Coriander, cultivated in Britain, is said to have white flowers, so I am inclined to think that, in this instance, the plant had been introduced with foreign produce and had not sprung from local kitchen-refuse. In the Bristol district it is a rare stray. It seems odd that a herb afflicted when fresh with such an offensive odour (the name is from *koris* because the green plant, seed and all, stinks of bugs) should yield from its fruit, when distilled in this country, an essential oil particularly delicate and agreeable in flavour.]

Galium Vaillantii DC. Still in St. Philip's Marsh, G., as a casual; *G. C. Druce.* Abundant in cultivations on the peat near Shapwick and Ashcott Stations, 1913 and subsequently; *Marshall* in *Fl. Som. Suppl.*

G. erectum Huds. G. Several patches in a pasture by the road-side between Stapleton and Hambrook, conspicuous when in full flower at the beginning of June.—S. Walton-in-Gordano! *Rev. E. Ellman.*

× *G. ochroleucum* Syme. Stinchcombe Hill, near Dursley, a new record for Gloucestershire; *Miss Roper.* Furzy pasture between Gatcombe Court and Providence, S.! *Id.* Roadside bank on Tickenham Hill! *C. Bucknall.* Cheddar; *H. S. Thompson.*

Filago minima L. Still at Hanham, G., after an absence of some years: about 30 plants in Fry's station, 1917; *Miss Roper.* On the coast north of Clevedon, S., with *Gnaphalium sylvaticum*; *Rev. E. Ellman.*

Gnaphalium sylvaticum L. Drove in Asham Woods, S., 1917; *Miss Roper.*

Doronicum Pardalianches L. Although not seen for many years in the Glen Frome locality (*Fl. Brist.*, 378), it is still there.

Crepis biennis L. Hillside between North Nibley and Wotton-under-Edge! *C. Bucknall.* Plentiful between Clevedon and Kingston Seymour, S.; *Miss Livett.* The single plant noted near Nailsea Station by Miss Roper in 1900 was the probable parent of a multitude that now covers the whole embankment at the spot.

[*Hieracium pratense* Tausch. Established on walls at Brislington, S.! *Miss Roper.*]

[*Orobanche ramosa* L. Still on rubbish in St. Philip's Marsh! *Lady Davy.*]

[*Verbascum Chaixii* Vill. On the edge of the large quarry at Providence, Long Ashton, several plants, 1915-17! *Mr. Reginald Price.*]

Rhinanthus stenophyllus Schur. New to the district. G. Compton Greenfield; and Yate Lower Common; *Miss Roper.* Naming confirmed by Mr. Marshall.

Euphrasia campestris Jord., var. *neglecta* Bucknall in *Journ. Bot. Suppl.* 1917, 19. Plentiful along the southern exposure of the limestone ridge that extends from Ashton Park to Clevedon. Hitherto confused (by me) with *E. brevipila*; or with *E. nemorosa*, the species which almost invariably accompanies it, and to which it is so similar in habit and characters of flowers and foliage that it can only be distinguished by the short glandular hairs. A recent gathering from gravelly soil at Tyntesfield has the general appearance of *E. gracilis* though densely glandular. Mr. Bucknall wishes it to be clearly understood that other students of the genus may well take a different view of this plant, but he cannot see his way to connect it with the very distinct typical *E. brevipila* as found in many parts of Great Britain.

Mentha Pulegium L. Mr. Druce (*Bot. Exch. Club Report,* 1916, 498), vouches for this from "Wrington, Somerset, on the edge of a wood; *Miss Todd.*" Certainly new to this district and possibly to the county. Miss Roper, who has seen the locality, considers the plant to be a native.

Origanum vulgare L., var. *megastachyum* Link. On Lyncomb Hill, Sandford, S.!

Cyclamen hederæfolium Ait. By the kindness of the present owner I have been enabled to make a careful examination of the Congresbury locality (*Fl. Brist.* p. 494) and its surroundings. The spot proves not to be a shrubbery in any sense, but is an outlying bit of aboriginal limestone woodland which, although now detached and included in a small private holding, originally formed part of the extensive range of woods that cover the uplands between Brockley, Congresbury and Wrington. Amongst thick underwood and in

company with *Tilia cordata, Rubia, Lithospermum purpureo-cæruleum, Polygonatum officinale,* etc., the *Cyclamen* occurs in scattered patches, a dozen or more, over a space of at least 100 yards. A good patch has appeared in the interior of Portishead Wood, not near any cultivation ; *Miss Winsome Bartlett.*

Polygonum minus Huds. Boggy ground at Priddy, Mendip, 1917 ; *B. W. Tucker.* Is still on the peat at the locality where it was found by the author in 1895, and has lately been seen in another place by Mrs. Sandwith.—var. *subcontiguum* Wallich. A small state from the Mineries on Mendip, *B. W. Tucker* (see *Journ. Bot.* 1917, 188).

Orchis prætermissa Druce. Plentiful on the Clapton side of the Walton valley. Noticed and determined by C. Bucknall. Max Bog, Winscombe ; *Miss Roper.*

Habenaria bifolia R. Br. Wrington Warren, S., ten or twelve plants ! *F. Samson.* In two enclosures on the moor near Weston-in-Gordano, S., 1917 ; *Mrs. Sandwith.*

[*Narcissus poeticus* L. Two patches of about a dozen roots each among Yews, Birches, etc., on Brockley Warren, S., far from any building or cultivation, a plant or two of *N. major* there also. Doubtless the work of some misguided planter.]

Potamogeton Drucei Fryer. New to Bristol and to Somerset. First gathered in the Avon at Saltford, August, 1916, by Mr. Bucknall, in company with Mrs. Wedgwood, who afterwards suggested that it agreed with the description of *P. Drucei.* In July, 1917, several large patches of the plant were seen between Kelston and Saltford Locks. These had well-developed broad floating leaves, as well as long-petioled lanceolate submerged ones. In August the broad leaves were still more abundant, while the others had nearly disappeared. Mr. Druce, himself, on seeing the 1916 specimens, at once agreed to the name *P. Drucei* ; and Mr. Bennett, after examining a complete series, said there could be little doubt they were Druce's plant. In view of the opinions of Fryer and Hagström that *P. Drucei* may be the hybrid *alpinus* × *natans*, it must be noted that the Avon specimens do not show the red colour stated to be present in the Loddon plant, and that *P. alpinus* has not yet been met with in the Avon. Mr. Bucknall could not find any fruit or flower.

P. Friesii Rupr. was lamented as a loss in this district through the recent destruction of the old coal canal that connected Camerton and Midford with the Avon. But fortunately the plant survives in the river, where we were ignorant of its presence until Miss Roper raked out a little (not flowering) in August last.

P. pectinatus L., var. *diffusus* Hagström. Brackish ditch near the Channel at St. George's Wharf, S. ; *H. S. Thompson*. Named by Mr. A. Bennett.

Zostera marina L., var. *angustifolia* R. At low water in Kewstoke Bay, S. ; *Mrs. Sandwith* and *Miss Roper*.

Carex pallescens L. Lower Woods, Wickwar, G., *C. Bucknall*. Again reported from "an open glade" of Leigh Woods by Mr. Noel Sandwith ; and I have seen it there in some plenty. Abundant near Hallatrow ; *R. V. Sherring*.

Lastrea spinulosa Presl. Fry's Bottom, Chelwood, S. ; *Miss Roper*. Walton Moor ; *Id*. Max Bog, Winscombe ; *Id*. Asham Woods ; *R. V. Sherring*.

Nitella opaca Ag. In an old strontia pit S.W. of Yate Court, G., June, 1917 ; *Mrs. Sandwith*.

N. mucronata Miquel. The species is rare in Britain and unknown in the Western counties. In a pond (one of a series of old strontia pits) S. of Hall End, near Wickwar, April, 1917, G. ! *Miss Roper*. Found in good quantity and fruiting well. The careful examination of a series of gatherings by Canon Bullock-Webster and Mr. James Groves has led to Miss Roper's plant being described as a distinct variety—var. *gracillima* : see *Journ. Bot.*, 1917, 323.

N. intricata Braun. (Leonh.). New to the Bristol flora. Discovered, May, 1917, by Mrs. Sandwith in a small muddy pool (a strontia pit) N. of Yate Church, G. !

Chara fragilis Desv. A first record for the typical plant in the West Glouc. division of the district. In a pond (once more a strontia pit) on the skirt of Yate Lower Common, June, 1917 ! These ponds or pits in the vicinity of Yate—there are several hundreds of them—from which so many good aquatics have been taken, are small excavations in the grits and sandstones of the locality, made in extracting the strontium ore that occurs in pockets near the surface, a process still going on. Although often only a few feet in area, they are seldom filled up when done with ; water collects at once on the impervious rock and vegetation quickly follows. As the ponds are artificial the plants must be introductions, so here again we see the work of wild-fowl, and interesting work remains for us in a search for the original habitats or headquarters from whence the aquatics have been brought. Such sources may lie at a considerable distance, perhaps far beyond our limits.

Aliens.—Our city refuse-heaps, grain-sifting plots, and fowl runs continue to yield crops of foreign weeds. Those that occur with a certain regularity either on the same ground or in similar localities in the district are the more noteworthy: others, seen once only, are of but little importance. To some extent they give indications of the economic life of the people upon whose cast-out rubbish they spring up. Amongst examples of the cereal and vegetable foodstuffs in daily use we find tiny date palms, millet, an occasional pumpkin, or an Asiatic bean ; and whilst in pre-war days the household Caraway was not infrequent, now that it cannot be obtained and Dill with a similar flavour is largely substituted, plants of the latter, very rarely seen before, are often met with. Although the mode of introduction of such casuals is usually manifest, there are exceptions. Whence, for instance, came the fine plant of *Solanum rostratum*, that lately appeared on newly-broken ground in Woodland Road, Clifton ?

"Local Coast Erosion and Its Cure."

By Ida M. Roper, F.L.S.

(Read 1st November, 1917.)

It has always been a matter of great interest to some landowners that the sea, by its tides, continually washes away tracts of land bordering on it, or else is depositing sand or mud, and in that way adds by degrees to the dry land around the coasts.

In the one case the owner loses his land with any buildings upon it, and in the other he has some useful land added to his property. These changes have been going on for centuries in England and everywhere, but it is usually a very slow process, and its effects are not marked seriously in the life of any one owner.

Geologists tell of raised beaches, and great flats of land where there have been gains, and of shallow depths in the sea where the lost ground has been swallowed up. It is not needful to dwell on these ancient times, but you will recall that the Glastonbury Vale has gradually become dry land, and the flats between Avonmouth and Berkeley have been formed in much the same way, whilst the modern Weston-super-Mare is largely built on sand that was formerly the Channel shore. In this part of the kingdom we are fortunately exempt from much decrease or increase of land in modern times from the action of the Bristol Channel, but on the East Coast of England, north of Ipswich, the destruction is great, and yearly the sea washes away valuable property. Those of you who have visited Cromer know how villages and churches have been abandoned by the inhabitants, and swallowed up.

A few hundred years ago a considerable tract of land is believed to have been destroyed a little higher up the Severn than the present Avonmouth Docks, and in a small way we see similar destruction by the waves carried on against the banks of the river Avon near Sea Mills. Such coast erosion, or eating away of the dry land by the action of the waves, has of recent years received a good deal of attention from the Government, and from scientific people at the instigation of the landowners, who see their property slowly disappearing, and have to spend large sums of money to try and put a stop to it.

Nearly 150 years ago in this district the owners of the flats from Berkeley to the River Avon, with the help of the Government, combined together, and went to the expense of building an earthen, and in some parts a stone bank, some 10ft. high, all along the edge of the Channel, a little distance above high-water mark. In this way they prevented specially high tides, in combination with strong gales, from washing away the surface of the neighbouring land, and they followed up this gain by a careful system of drainage which enabled them to sow grass and convert the hitherto useless marsh into valuable pasturage.

In course of years similar extensive works were carried out both higher up the Severn and lower down as far as Bridgwater, at those parts where such sea banks would give protection to the land behind.

This system of guarding the land answered very well, although a certain amount of ground between the sea bank and the high-water mark was being constantly eaten away by the exceptionally heavy weather. But that had been foreseen, and the land being of little value for feeding purpose, because of the large quantity of salt contained in the soil, the owners allowed it to go on unchecked. In other parts of the kingdom, however, the losses of valuable land from similar causes had become so serious that about 1907 the Government appointed a Royal Commission to enquire into the facts and to suggest remedies. Before this Commission all kinds of experts gave evidence, including trained botanists, and these latter gentlemen pressed their views that much good might be done to lessen or perhaps to stop coast erosion by planting and cultivating certain plants which they named. They pointed out that those plants would live in the mud or the sand, and could, moreover, by their very numerous roots, bind together either of these soils, and so make them, at the start, sufficiently firm to withstand the scouring action of the waves, and later on, by the great increase in their growth, raise the level of the ground gradually out of the reach of all such scouring action.

It was an idea carried into practice by the Dutch to strengthen their dykes or sea-banks by planting certain rushes and Equisetum, and by the people on the East Coast of England to keep the loose sand in a stable condition, and so prevent the wind from carrying it over their pastures inland. They used the Marram grass, *Ammophila arenaria*, and Nature had shown the way by growing immense tracts of it in a wild state on the southern shores of the Baltic. The experts, however, before the Commission, recommended other plants in addition to these, and what they urged was prominently brought out in the final Report presented to Parliament. This Commission in another form is still watching the results of their various recommendations, and giving advice on the best means of combating the constant erosion caused by the sea.

Amongst the grasses recommended to be planted was a species of Spartina, which from its nature was specially suitable where soft mud was the only protection against the erosion of the earth banks adjoining, and as these are the conditions met with on the shores of the Severn in North Somerset, the planting of this particular grass became of special interest to the landowners about this neighbourhood.

Spartina belongs to a small genus of which one species only is indigenous in England about Lincolnshire, and the others are chiefly American. The native one, *Spartina stricta*, established itself at Hythe about 1870, where it flourished, mingled with another species, *Spartina alterniflora*, of American origin. About 10 years later a few plants were noticed of another grass, which appeared to be a hybrid formed between these two species. The difference was recognised by the brothers Groves, the well-known botanists, and they named the new grass *Spartina Townsendi*, in honour of Mr. Frederick Townsend, the botanist who had done so much to record the flora existing in Hampshire.

For some unknown reason this new hybrid was especially adapted to grow in the sea waters around our coast, and in 20 years it had spread to most of the adjoining bays along the English Channel, especially those muddy ones leading out from Southampton waters, and the deep estuary, which forms Poole Harbour in Dorset. In such creeks small tufts would be noticed, and in a year or two they had become surprisingly numerous. Some years were apparently much more favourable than others for the increase, but whatever the cause by this time it covers thousands of acres of mud-flats in Southampton Waters and Poole Harbour, and it serves to show how Nature multiplies her products when favourable conditions prevail, and no competition is present.

This new species of *Spartina Townsendi* is a vigorous stiff grass reaching usually 2½ ft. in height, with rigid leaves, long and pointed, standing off at an angle of about 60 degrees. These rigid outstanding leaves are characteristic features and easily distinguish it from the other two kinds. The stems and leaves are coloured a bright green when young, but turn in autumn to a brown hue with a beautiful golden sheen resembling ripe corn.

On top of the solitary stem are the flowers in a stiff, branched spike, growing at one side only of each branchlet, and these form pretty feathery heads due to the long stigmas and anthers protruding from their glumes. This takes place about early August, and in due time by wind fertilisation seeds are produced in vast numbers in some years and with a very poor crop in others. Although the seeds no doubt give rise to a great number of new plants, this species of Spartina has another method of spreading rapidly.

Each stem anchors itself by a long tap root descending well into the mud, whilst from the base of the stem just underneath the surface another set of roots are given off in all directions which may be from a few inches to many feet in length, and these in their turn take root at the nodes and give rise to new plants. This method of growth causes the grass to form circular tufts, which go on increasing to many feet in diameter until the spreading brings them in contact with other similar tufts, when the two join, and so

produce large masses of closely interwoven roots to bind the mud together, and in a few years regular fields or meadows of the grass appear where the mud had been in undisputed possession.

It will be observed that soft mud has played a very important part in the spread of the grass, because it is able from its nature to flourish in such mud when there is not too much sand present, and where practically no other plants are able to establish themselves in competition.

It cannot grow apparently at all places, where such soft mud exists, as the plant will not survive being constantly covered by salt water ; but it will flourish when covered by $2\frac{1}{2}$ ft. of water at ordinary high tides. It appears to be checked nearly completely if the depth exceeds 3 ft., whilst in shallower waters nearer the land it will put up with every hardship. Hitherto the growth of this particular species in England has been in quiet waters away from strong tides and the beating of heavy waves, and it may prove that such backwaters and river estuaries are its abiding home.

As has been stated, the grass made its appearance in Poole Harbour of its own accord, being first noticed there in 1899, and last year there were hundreds of acres of former mud covered with it in such masses that cattle were able to roam and feed upon it without danger ; and there were hundreds of acres more of the grass through which the tides of the harbour flow daily, and deposit a small extra layer of mud, which will evidently in a few years convert those wet fields into dry land fit for feeding.

It will thus be evident that a plentiful growth of *Spartina Townsendi* on a bare expanse of soft mud, daily washed by a moderate tide, is capable of converting quickly such mud-flats into dry land that stands above the level of ordinary tides ; and if it proves capable of doing similar useful work in the presence of strong tides, a great help will have been obtained to check the constant washing away of muddy shores, and by raising them up will in a short time form a barrier against the erosion of the sea on the adjoining earthbanks.

So far no example is known where such an experiment has gone on long enough to show if the grass will flourish under the conditions stated, and therefore it is with particular interest that I have this year visited a stretch of ground below Clevedon where the Spartina has been deliberately planted to test the result. It is planted on a wide expanse of mud exposed to the strong currents of the Severn, and to very heavy beating waves whenever the prevalent South-West winds blow strongly in upon it.

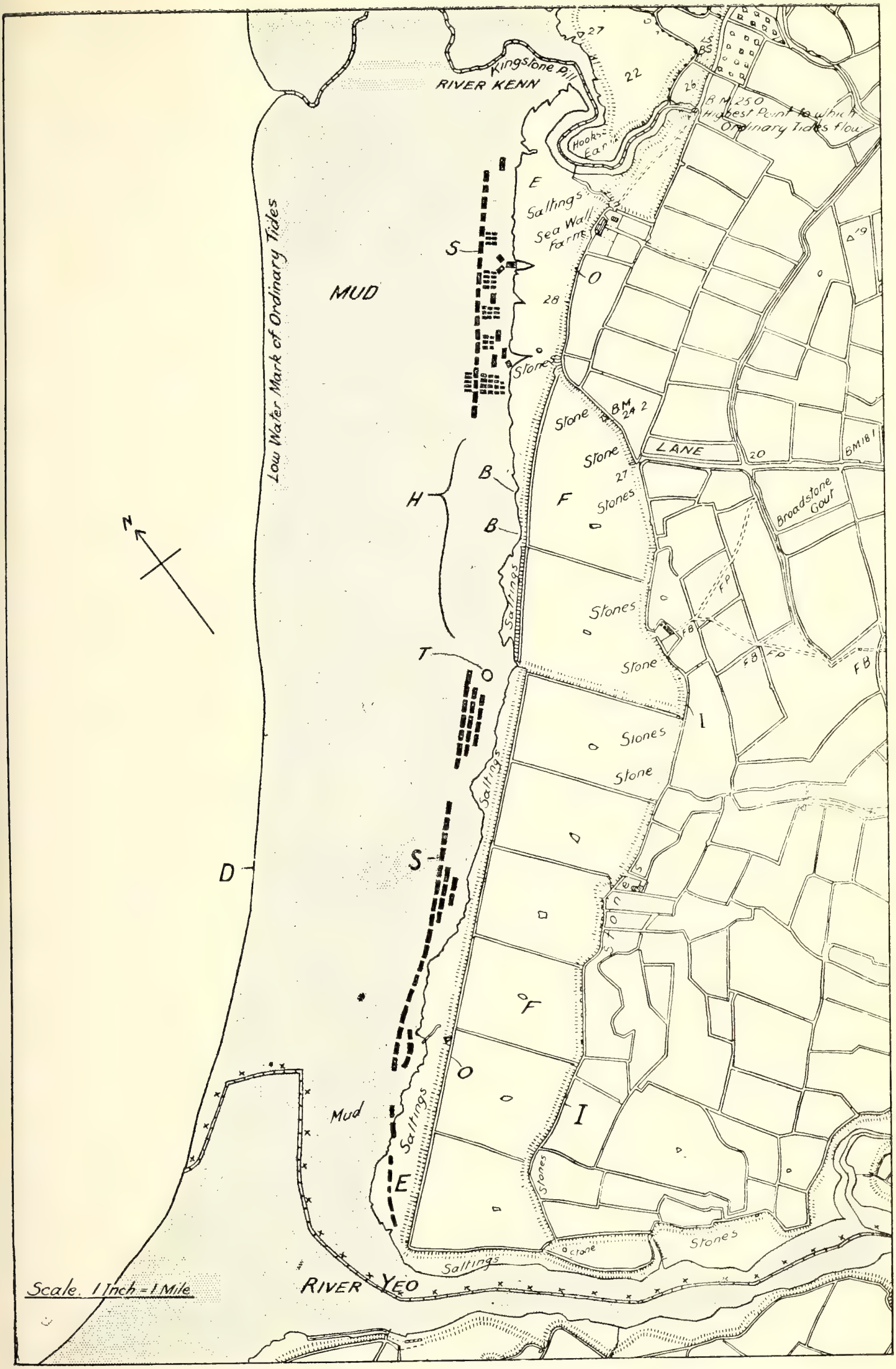
Four years ago the Rev. E. Ellman, a botanist who lives at Clevedon, told me that he had seen some *Spartina Townsendi* a few miles below the town, and he thought it had come there spontaneously until he came upon a man who was planting a number

of tiny tufts in the mud. There the matter rested until the present autumn, when I and my brother made special visits to the spot, to see if anything had happened as a consequence of the planting.

When on visits to Dorset I had observed the immense spread of the grass in Poole Harbour and around some of the bays of the Isle of Wight, but I was none the less thoroughly gratified to see that it appears to have established itself within the last four years on the mud below Clevedon, where the sea conditions are so very different. The scene of the Clevedon experiment is about 3 miles south-west of the Old Church at Clevedon towards Kingston Seymour and Woodspring, between the estuaries of the Kenn and the Yeo. Inland there are fields, the outer one being over a mile long and protected carefully by two lines of sea banks, the two barriers being built to make sure that if the front one is broken through by the force of the strong waves that beat in at that particular part, the water shall not be free to flood hundreds of acres of grassland that lie behind, only a few feet above the level of high-water mark. (*See map*).

Outside the front sea-bank is a flat stretch of grass land called saltings, or salt marshes, in parts some 20 ft. straight up above the mud, and in others much less, very narrow in their width, and constantly becoming narrower by the erosion of the waves and tide. In fact, it looks as if all this salting would have disappeared by this time, had not the authorities put in stretches of stone facing to the earth-bank at the weakest spots. At the South-West end the loss is considerable, whilst harder ground and the stone facings have checked it further up towards Clevedon. Seaward there is a stretch of soft, sticky mud some 600 yards in width, extending to low-water mark, and the object of the experiment of planting Spartina was to find out if it would grow on the mud in sufficient masses to check the force of the waves from further eating away the saltings, already so nearly destroyed close up to the protecting sea bank.

It is apparent that success is likely to attend the trial. There are sure signs of a vigorous and healthy growth of the grass, as the dots on the mud show that it has already obtained a good foothold, and the circular tufts are becoming much larger ; and whilst coming close together in some parts, are in others arranging themselves into miniature meadows across the run of the tide. The number of tufts amount to several thousands, and as the mud is continuous into the bank they can send up new plants in a rapid growth by means of their far-reaching roots. It is noticeable that the outermost tufts run in a nearly straight line, and this probably marks the spot where the mud is covered at ordinary tides by 2 to 3 ft. of water, and left dry again after a short time of immersion. The distance of this line is from 50 to 100 yards out from the sea bank. At one part, about one-third of a mile in length, no tufts of grass



MAP OF THE DISTRICT.

(From the "Kew Bulletin," by permission of H.M. Stationery Office.)

appear to have taken root, and this may be where the beating of the waves during rough weather is particularly strong, because the sea-bank on the shore opposite this stretch has been breached recently by such waves, and the path along it cannot at present be used. From enquiries made it was learnt that the landowner had shown a practical belief in the advantages to be obtained from scientific knowledge, and had determined to apply its teachings to protect his land from further erosion, and no doubt to lessen the cost of putting stone facings to the saltings and of repairing the sea-banks. He is stated to have procured three years ago from Hayling Island a quantity of *Spartina Townsendi*, which he had split up into one thousand small tufts, consisting of two or three plants in each, and these he planted one yard apart in a straight line in the mud close against the upright earth-bank of the saltings. The waves, however, would have none of this, and promptly floated them all out, and deposited them 40 or 50 yards seaward. Here most of them fortunately took root, and gradually settled down in a more or less straight line opposite the part where they were originally planted, with many of them shifted nearly half-a-mile northwards.

The little tufts have increased greatly in number and grown remarkably in size, many of them being after three years' growth, more than one yard in diameter, and are scattering about many offshoots. Scarcely any of the tufts, however, have so far had time to grow sufficiently large to join actually together, and all of them in their present position are covered by a foot or two of water at each tide for one or two hours. If the present rate of growth goes on with equal rapidity the mud will soon appear with a thick vegetation upon it, and to judge by the inspection of one of the present tufts, the hitherto soft mud will give sufficient support for a man to stand upon the ground without making more than a footmark.

The numerous stems keep back amongst them during each immersion a tiny quantity of mud, which serves to raise the ground a little and allow the roots to hold it together, and at the same time a certain amount of sand brought in with the tides is left on top, which still further makes firm the mud. Three years is a very short time to watch such changes, and it will be interesting to see in the near future if the Spartina can hold its own against the force of the waves, and increase in such quantities as to render their beating action of small account, after they have travelled across the thick growth to the foot of the saltings. If the waves lose their force at this spot the experiment will have been a success, and it may be anticipated that a further growth of the grass will line the foreshore with a stretch of firm ground that will protect the sea-bank more effectually than was done by the original saltings, when they were left outside for that purpose.

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	Mappin, S. W.	100, Pembroke Road, Clifton, Bristol
	Matthews, H. E.	Hillcroft, Nore Road, Portishead
A	Matthews, L. H.	6, Peas Hill, Cambridge
	McIntyre, Miss	67, Claremont Road, Bristol
A	Merrell, E. J.	34, College Green, Bristol
*	Morgans, Thos., M.I.C.E.	7, Elton Rd., Tyndall's Park, Bristol
	Morgans, Mrs.	7, Elton Rd., Tyndall's Park, Bristol
A	Mortimer, Mrs. C.	4, Cambridge Park, Bristol
A	Mullock, Miss	23, Berkeley Square, Bristol
	Norman, G., M.D.	12, Brock Street, Bath
	Odell, Miss D. A.	22, Berkeley Square, Clifton
	Potter, Miss M. H.	40, Alma Road, Clifton
*	Prowse, A. B., M.D.	5, Lansdown Place, Bristol

A	Prowse, Mrs.	5, Lansdown Place, Bristol
A	Prowse, Miss	33, Caledonia Place, Clifton
	Rafter, J., M.A.	The University, Bristol
	Read, E. H.	72, Victoria Road, Bedminster
*	Reynolds, S. H., Sc.D., F.G.S.	13, All Saints' Road, Clifton
	Richardson, Frank	15, Percival Road, Clifton
*	Roper, Miss I. M., F.L.S. ..	4, Woodfield Road, Redland, Bristol
*	Rudge, C.K.,L.R.C.P.,M.R.C.S.	145, Whiteladies Road, Bristol
A	Salmond, P. W.	9, Oakfield Place, Clifton
	Salter, Mrs.	25, Harcourt Road, Redland, Bristol
	Samson, F.	4, Woodfield Road, Redland, Bristol
	Sandwith, Mrs.	26, Canynge Square, Clifton
A	Sandwith, N. Y.	26, Canynge Square, Clifton
	Scott, W. G.	25, Duke Street, Cardiff
	Seyler, C. A.	Nelson Terrace, Swansea
A	Shaw, Miss M. G.	25, Elliston Road, Redland, Bristol
	Shepherd, G. D.	Gresham Chambers, Kingsway, Cardiff
A	Sinnott, Jas.	15, Beaufort Road, Clifton
A	Smith, Miss A. M.	70, Pembroke Road, Clifton
A	Smith, Miss E. J.	70, Pembroke Road, Clifton
*	Smith, D. Munro, M.R.C.S. ..	73, Downs Park East, Westbury-on-Trym
	Smith, H. C.	13, Acraman's Rd., Southville, Bristol
	Smith, W. A., M.B.	70, Pembroke Road, Clifton
A	Smith, Rev. W.	17, Vyvyan Terrace, Clifton
A	Smith, Mrs. W.	17, Vyvyan Terrace, Clifton
	Stanton, D. W.	42, Alma Road, Clifton
	Stanton, Mrs., ...	42, Alma Road, Clifton
	Stewart, D. McDonald, F.G.S.	25, Woodstock Road, Bristol
†	Strickland, Thompson ..	13, Victoria Square, Clifton
	Sulley, H. T.	Scottish Widows' Buildings, Bristol
*	Tutcher, J. W.	57, Berkeley Rd., Bishopston, Bristol
A	Underhill, J. T.	2, Brynland Avenue, Bristol
	Vaughan, Mrs.	42, Fernbank Road, Redland, Bristol
	Walton, J. C. H.	18, West Park, Bristol
	Warren, Mrs. Crosby	15, Upper Belgrave Road, Bristol
A	Webb, H. Vicars	122, Sefton Park Road, Bristol
A	West, Mrs. A.	5, Devonshire Road, Westbury Park
*	White, Jas. W., F.L.S. ..	18, Woodland Road, Clifton, Bristol
	White, Mrs.	18, Woodland Road, Clifton, Bristol
*	Wickes, W. H.	16, Oakfield Grove, Clifton
	Wills, G. A.	Burwalls, Leigh Woods, Bristol
	Wills, W. M.	Bracken Hill, Leigh Woods, Bristol
	Wilson, E. A.	Southey House, College Green, Bristol
	Womersley, H.	17, Devonshire Road, Westbury Park, Bristol
	Wingate, Miss H. M., M.A. ..	40, Alma Road, Clifton
A	Woodey, E. L	
	Worsley, Miss I.	Rodney Lodge, Clifton
	Yabbicom, T. H., M.I.C.E. ..	23, Oakfield Road, Clifton

Honorary Members.

Prof. George S. Brady, M.D., LL.D., D.Sc., F.R.S., F.L.S., Park Hurst, Endcliffe, Sheffield.

Henry J. Charbonnier, Haw Lane, Olveston, Tockington R.S.O., Glos.

Prof. C. Lloyd Morgan, LL.D., F.R.S., F.G.S., 5, Kensington Place, Clifton, Bristol.

R. M. Prideaux, F.E.S., Brasted Chart, Nr. Sevenoaks, Kent.

Prof. H. S. Hele Shaw, M.I.C.E., LL.D., F.R.S., 64, Victoria Street, Westminster, SW.1.

Prof. W. J. Sollas, M.A., LL.D., F.R S., F.R.S.E., F.G.S., University Museum, Oxford.

Sir W. A. Tilden, D.Sc., F.R.S., Professor of Chemistry in the Imperial College of Science, S. Kensington, S.W. 7.

William Whitaker, B.A., F.R.S., F.G.S., Freda, Camden Road, Croydon.

Prof. Sydney Young, D.Sc., F.R.S., Trinity College, Dublin.

REPORT OF COUNCIL.

To December 31*st*, 1918.

THE decision to continue the Meetings so that members could at intervals find relaxation of thought from trying conditions of the year has proved a success.

The attendances have been satisfactory in spite of the dark and dangerous state of the streets, and even more gratifying is the fact that there have been only two resignations, whilst in addition the membership has steadily increased by 17 new members joining, made up of 13 ordinary with four associates.

The total number in the Society at the end of the year is 121 members.

Loss by death has been sustained of two old members Mr. Francis J. Fry and Mr. M. W. Dunscombe, who have been long connected and interested in different branches of work in the Society, and of Prof. George Lebour, Vice-Principal of Armstrong College, Newcastle, one of our honorary members. The Society had the honour of adding the name of Dr. C. Lloyd Morgan to the list of honorary members in recognition of his distinguished work for science.

We have issued the Society's "Proceedings," so as to complete the volume to the end of 1916, and have distributed them to the ordinary members and to Corresponding Societies ; and the first part of the next volume has been prepared, and is in the press.

Early in the year Dr. Darbishire proposed an addition to Law 2, for the Society to give definite teaching courses to help forward Natural History studies. After long consideration, Council agreed to the spirit of such a change in the objects of the Society, but unexpected difficulties caused it to be abandoned.

In June, the Summer Excursion took place, and this side of the Society's work might receive further consideration if a number of members could be relied upon to attend.

Eight meetings have been held during the year, at which exhibits were shown, and papers read on attractive subjects, including one by our member, Dr. W. E. Hoyle, of the National Museum of Wales.

IDA M. ROPER,

Hon. Secretary.

The HON. TREASURER in Account with the BRISTOL NATURALISTS' SOCIETY.

DR. GENERAL ACCOUNT FOR THE YEAR 1918. CR.

	£	s.	d.
To Members' Subscriptions—			
Ordinary	15	10	0
Associate	4	0	0
,, Entrance Fees	1	10	0
,, Subscriptions in advance	1	0	0
,, Arrears collected	11	15	0
,, Donations	1	10	0
,, Sale of "Proceedings," etc.	4	18	5
,, Balance forward from 1917	72	9	8
,, Balance due to Hon. Treasurer ..	1	1	7
	£113	14	8

	£	s.	d.
By Subscriptions to Societies—			
Ray	1	1	0
Commons and Footpath		10	6
Taylor's Crustacea		10	6
,, Cost of "Proceedings," 1915–16 ..	43	6	6
,, Printing	2	4	0
,, Fire Insurance		7	6
,, Rent of Library and Rooms	7	14	0
,, Postages, etc.	6	5	3
,, Gratuities	2	0	0
,, Cash in hand and Bank	49	15	5
	£113	14	8

Audited and found correct,
ERNEST H. COOK,
CHARLES BARTLETT, A.C.A. } *Auditors.*

December, 1918.

LIBRARIANS' REPORT.

For the Year 1918.

DURING the past year some practical use has been made of the Library by members consulting books there, but only 15 have used the privilege of borrowing any for further study, and these numbered 80 volumes. Eight books of recent issue are still in use, and three taken out in 1917 have not been returned.

No volumes have been bound during the year.

We have received a number of current publications from many of the Corresponding Societies, but they have reached us in an irregular series, and under present conditions it is not certain that all the Societies have issued "Proceedings" for this year.

Thanks are given to the following donors of books, etc. :—

Mr. A. E. Hudd, F.S.A. Lowe : *British and Exotic Ferns.*

Mr. J. W. White, F.L.S. *Journal and Proceedings,* Botany and Zoology, *of the Linnean Society,* 1918.

Lieut.-Col. A. B. Prowse, *9th Report of the Botanical Committee of the Devonshire Association,* 1917.

Miss I. M. Roper, F.L.S. Newspaper Cuttings of B.N.S. Meetings for 1862 and 1863.

Entomological Section, B.N.S. The Entomologist and *Entomologist's Monthly,* several parts.

Here again it is probable that publications usually given have not been issued, including those due to us by subscription.

By purchase, 14 volumes of the *Somersetshire Archæological and Natural History Society's Proceedings,* from 1849-1867 have been added to complete the early series in the Library.

Croydon Natural History and Scientific Society has been added to the Exchange list, and we have received 36 volumes of its *Proceedings* and *Transactions* from 1871 onwards, and given in return a still more complete set of our own publications.

The demand for the sale of back numbers and reprints has increased, and in most cases have been supplied.

In response to the demand by Government for waste paper, for re-manufacture, 2 cwt. of surplus material has been sold.

ARTHUR B. PROWSE, Lieut.-Col., R.A.M.C.,
Hon. Librarian.

IDA M. ROPER, F.L.S.,
Hon. Sub-Librarian.

Exchange List.

Ashmolean Natural History Society of Oxfordshire
Barrow Naturalists' Field Club
Belfast Naturalists' Field Club
Birmingham Natural History and Philosophical Society
Bristol Museum and Art Gallery
British Association
British Museum (Natural History), S.W.
Cardiff Naturalists' Society
Chester Natural Science Society
Cornwall, Royal Geological Society of
———, Royal Institution of
———, Royal Polytechnic Society
Cotteswold Naturalists' Field Club
Croydon Natural History and Scientific Society
Ealing Scientific and Microscopical Society
Edinburgh Geological Society
——— Royal Botanic Society
Essex Field Club
Geological Society of London
——— Survey and Museum, London
Geologists' Association
Glasgow, Geological Society of
———, Natural History Society of
——— Philosophical Society
Hertfordshire Natural History Society and Field Club
Liverpool Geological Society
——— Literary and Philosophical Society
——— Science Students' Association
Manchester Literary and Philosophical Society
——— Microscopical Society
——— Museum Library
Marlborough College Natural History Society
Norfolk and Norwich Naturalists' Society
North Staffordshire Field Club
Nottingham Naturalists' Society
Plymouth, Marine Biological Association of the United Kingdom
——— Institution, and Devon and Cornwall Natural History Society
Quekett Microscopical Club
Royal Irish Academy
Royal Microscopical Society
Rugby School Natural History Society
Torquay Natural History Society
Woolhope Natural History Field Club
Yorkshire Geological and Polytechnic Society
——— Naturalists' Union
——— Philosophical Society

Our "Proceedings" are sent as a free gift to:—

British Museum Library
Cambridge University Library
Dublin, Trinity College Library
Edinburgh, Advocates' Library
Oxford, Bodleian Library
Patent Office Library, London

AUSTRALIA.

Australasian Association for the Advancement of Science
New South Wales, Geological Survey
———, Royal Society of
Queensland Museum, Brisbane
Victoria, Royal Society of

CANADA.

Canadian Institute, Toronto
Hamilton Scientific Association
Nova Scotian Institute of Natural Science (Halifax)

INDIA.

Agricultural Journal of India
Agriculture, Imperial Department of
Geological Survey of India, Calcutta

FRANCE.

Lyon, Société Linnéenne de
Rennes, University of

NORWAY.

Det Kongelige Norsk Universitet Christiania

SWITZERLAND.

Lausanne, Société Vaudois des Sciences Naturelles
Zurich, Naturforschende Gesellschaft

UNITED STATES.

American Museum of Natural History, New York
Augustana College, Rock Island, Illinois
Boston, Mass., Natural History Society
Brooklyn Institute of Arts and Sciences, Coldspring Harbour
California, University of, Berkeley
Californian Academy of Sciences, San Francisco
Cincinnati Natural History Society
————, Lloyd Library
Colorado College, Colorado Springs
————, University of, Boulder
Denison Scientific Association, Ohio
Elisha Mitchell Scientific Society, Chapel Hill, N.C.
Essex Institute, Salem, Mass.
Illinois, University of, Urbana
Indiana Academy of Science
Michigan Academy of Science
Missouri Botanical Gardens
———— Academy of Science, St. Louis
New Mexico, University of, Albuquerque
Ohio State University, Columbus
Oklahoma State University
Philadelphia Academy of Natural Sciences
—————, Wagner Free Institute of Science
Smithsonian Institution, Washington
Tufts' College, Mass.
United States Geological Survey, Washington
—————— National Museum, Washington
Yale University, Connecticut

ARGENTINE REPUBLIC.

Buenos Aires, Muses National de Historia Natural

URUGUAY.

Montevideo, Museo Nacional de

MEXICO.

Mexico, Sociedad Cientifica

GEOLOGICAL SECTION.
1918.

THERE were 40 Members on the Register at the end of the year, but a great many had not paid their subscriptions, chiefly students; it is doubtful if they had not left the Section without giving notice.

The meetings have been much better attended, the average number at each meeting being 25, and interesting discussions have followed the reading of the papers.

January 24.—Annual Meeting

Exhibition of Geological photographs. Prof. S. H. Reynolds, M.A., F.G.S., was re-elected President, and B. A. Baker, F.G.S., Hon. Secretary and Treasurer for the year.
The following papers were read :—

February 21.—"Some Geological Reminiscences" (illustrated by lantern slides) Prof. C. Lloyd Morgan, F.R.S.

March 21.—"Prehistoric Man" (illustrated by lantern slides) Miss G. Snowden

May 16.—"Fossil Plants" (specimens and microscopic sections illustrating the chief group of fossil plants and their nearest living allies)
Miss L. Batten, M.Sc.

October 17.—"Fossil Birds" (illustrated by lantern slides) Prof. S. H. Reynolds, M.A., F.G.S.

November 21.—"Algae and Rock Builders" (illustrated by lantern slides, specimens and rock sections)
Miss E. Bolton, B.Sc.

December 18.—"Corallian Rocks of England": Miss M. Tuck,

Unfortunately the financial position of the Section is in a very bad state, as so many subscriptions are unpaid. The Section is in debt to the Hon. Treasurer to the extent of £1 9s. 3d., and there still remains the rent due to the University for the use of the Theatre.

B. A. BAKER,

Hon. Secretary and Treasurer.

ENTOMOLOGICAL SECTION.

1918.

FIVE Meetings were held during 1918, but no papers were read and no excursions made. The following is a short record of the principal exhibits and notes brought forward :—

February 15—Mr. G. C. Griffiths was re-elected President and Mr. C. Bartlett Hon. Secretary. Mrs. Sandwith exhibited specimens of the dragonflies *Cordulegaster annulatus* and *Libellula quadrimaculata.* Miss Roper, Cherry-gall on oak leaf with hymenopteron *Dryophanta folii* bred from it. Mr. E. S. Baynes, living specimens of the woolly aphis and scale insects. Mr. A. E. Hudd, lepidoptera and diptera taken in February, 1918. Notes by Mr. C. Bartlett were read on the capture of a large number of the longicorn *Acanthocinus œdilis* in larval, pupal, and perfect states found in pine logs washed up from a wrecked vessel at Woollacombe in September, 1917, and a coloured drawing of the insect in various stages was shown, also specimens of *Vanessa c-album* from Portishead were exhibited. Mr. G. C. Griffiths, *Papilio bianor* and *P. maackii* from China and Japan.

March 18—Miss Roper, *Timarcha coriaria* and other coleoptera. Mr. N. Sandwith, *Pyrausta atrata.* Mr. G. C. Griffiths, living cases of a Psychid found by Rev. C. R. N. Burrows in Essex and made some interesting notes on their habits.

April 26—Miss Roper, Coleoptera. Mr. A. E. Hudd, Diptera, and Miss Bolton, larva of *Hepialus humuli.*

November 22—Miss Roper contributed a list of dipterous galls found by her in the Bristol District, containing 56 species. Mr. A. E. Hudd contributed notes upon the fungus gnats. Mr. L. H. Matthews, specimens of *Arge galathea, Hesperia linea, Chœrocampa elpenor* and *Saturnia pyri* from Salonika. Mr. G. C. Griffiths, three drawers of *Erycinidœ.* Mr. C. Bartlett, a box of lepidoptera taken this year at Portishead, including *Syrichthus alveolus,* var. *taras Tephrosia consonaria* and *Acronycta alni.*

A resolution was passed requesting the Bristol Museum Committee to place the large and valuable collection of insects in a more convenient and larger room for the better use of students. This was sympathetically acknowledged, with a promise that the question would come up as early as possible for serious consideration.

December 13—Mr. G. C. Griffiths exhibited a store box of European butterflies of the genera *Satyrus* and *Cœnonympha,* also of the family Hesperidæ, underside varieties of *Lycœna alexis* and *L. agestis.*

CHARLES BARTLETT,

Hon. Secretary.

Account of the Annual and General Meetings.

THE 55TH ANNUAL MEETING.

January 17th, 1918.

Mr. G. C. Griffiths, F.E.S., was re-elected President for the third time, with only minor alterations in Council and Officers. His Presidential Address was postponed.

THE 466TH GENERAL MEETING.

February 7th, 1918.

Mr. G. C. Griffiths, F.E.S., delivered his Presidential Address, entitled "Insects, their Lore and Legend" (printed in abstract on page 71).

Exhibits by Mrs. Sandwith, of *Tolypella intricata*, a new plant in the Bristol district, and the aliens *Centaurea solstitialis* and *Mentzelia albicaulis*; and by Miss Ida M. Roper, F.L.S., of three local dragonflies.

THE 467TH GENERAL MEETING.

March 7th, 1918.

"Dead Life and other things in Egypt," by Mr. C. T. Campion, M.A.

The lecturer showed about 50 slides, taken by himself from carvings on tombs and remains in Egypt, chosen to illustrate the manner in which the artists expressed their ideas of the traits of various animals, birds and fishes. Especially natural were some geese, a sacred cow, dancing girls and athletic contests. Parts of carvings of processions were included, and although the ignorance of perspective caused the beasts illustrated therein to appear almost grotesque, the artist had succeeded in portraying some of their fitful attitudes. These and the suggestions offered about the meaning of the pictures gave much enjoyment.

THE 468TH GENERAL MEETING.

April 4th, 1918.

"Familiar Birds of Prey," by Mr. H. Vicars Webb.

This title properly includes a number of birds that eat insects and harmful pests, whereby they are useful to maintain the balance of Nature, but for small damages at certain seasons are often slaughtered in forgetfulness of their good work all the year round.

Recent sanctuaries, however, are proving helpful to preserve and increase these birds. Apart from their usefulness, the habits of the various species are a constant joy to students, and this was made clear by the help of many coloured lantern slides to illustrate personal observations. The falcon or kestrel has taught lessons to airmen by its wonderful powers of flight and hovering, and whilst the little sparrow hawk is bold and paralyses its prey by terror, the golden eagle is itself most timid. The distinctive call of birds again are of interest, such as the screech of the barn owl, the hoot of the wood or brown owl, the mewing of the buzzard, the scolding scream of the jay, or the goose-like chatter of the heron.

Numerous points were brought out about feeding and nesting, with the devices for safety and concealment, and about methods of catching prey, as well as reference to local haunts, and the benefits to bird life in general during migration from rests now provided on certain lighthouses.

Exhibits by Mr. H. J. Gibbons, of eggs of *Bombyx Neustria*; by Miss Ida M. Roper, F.L.S., of a milk-white form of the Primrose.

THE 469TH GENERAL MEETING.

May 2nd, 1919.

"Birds and Brochs in Shetland," by Miss H. M. Wingate, M.A.

The island of Mousa in the Hebrides offers a specially favourable place for coming into close contact with both the wonderful bird life and the ruins of the houses of the ancient Norsemen. The Arctic terns contrast by their swallow-like flight as they skim to and fro around the human intruder with the frightened screams of gulls and oyster catchers, whilst the Shags are content to utter their deep, low croaks of protest as they stretch out their long necks and move their heads from side to side. The young can be seen in all their quaint moods, whilst at times the on-looker may experience the threats of violent attacks from the fiercer Arctic Skuas, and watch them force by actual blows the hard-won food from the less pugnacious gulls. Glimpses may be obtained by perseverance of the doings of the Greater Black-back Gulls, ravens, eider ducks and even of seals, to which by the best of good fortune may be added the excitement of a school of bottlenose Whales being driven into shallow water by the fishermen from the sea.

It was this same island of Mousa that Sir Walter Scott chose for the scene of some exciting parts of "The Pirate," and he tells of the ancient ruins called brochs. These were the fortified dwellings of Norse chieftains, and must have existed long before 900 A.D.

Formed of dry walling in the shape of a dice box, about 60 feet in diameter, they had, facing the inner courtyard, a number of superimposed galleries that formed the dwelling rooms, and without, other houses for the retainers protected by another lofty wall. The lecture was illustrated by a fine series of lantern slides.

Exhibit by Mr. H. J. Gibbons, of *Carex digitata* and *Polystichum lobatum* from the Leigh Woods.

ANNUAL EXCURSION.

June 8th, 1918.

The summer excursion took place along the right bank of the River Avon to Sea Mills, in order that members might have the advantage of the presence of Prof. S. H. Reynolds for geology, Dr. O. V. Darbishire for lichens, and Mr. C. Bucknall for wild flowers. These gentlemen pointed out and explained the numerous features seen in the Gorge to an interested company.

THE 470TH GENERAL MEETING.

October 3rd, 1918.

Exhibits of Natural History by the Members.

The President, Mr. G. C. Griffiths, F.E.S., collection of entomological specimens captured locally and at Lynton, including the scarce Chalk Hill Blue.

Mr. J. W. White, F.L.S., fossil *Stigmaria ficoides*, from cutting near the place of meeting ; and the air-bladders of the Bream.

Mr. J. C. Blackmore, F.G.S., specimens of Lias from Lyme Regis.

Mrs. Sandwith, rare Lepidoptera ; herbarium specimens of *Andromeda polifolia* from Yorkshire ; species of Horned Poppies ; and *Potamogeton lucens*, var. *acuminatus* from Worcestershire.

Mr. H. J. Gibbons, *Ophioglossum vulgatum* with trifid spike.

Prof. S. H. Reynolds, Sc.D., series of limestones from Black Rock Quarry, Clifton, including some containing nodular lumps thought of late to be fossil algae ; and some volumes of Geological photographs on loan by the British Association.

Mr. L. H. Matthews, birds' eggs ; fasciated growth of *Carlina vulgaris* ; and rare Lepidoptera.

Miss Ida M. Roper, F.L.S., *Ornithopus perpusillus*, from Providence, Long Ashton, as likely to prove the westward extension of the Millstone Grit (see *Proc., B.N.S.*, 1888) ; *Rubus saxatilis*, and *Cladium Mariscus* a first record from the Gordano Valley.

THE 471st GENERAL MEETING.

November 7th, 1918.

"The Charophytes," by Mrs. Sandwith.

(Printed on page 76.)

Exhibits by the President, Mr. G. C. Griffiths, F.E.S., of hornets taken by Colonel T. Jermyn from a nest at Westbury, Wilts, in which he counted 265 males, 102 females and 120 workers, an unusually large colony ; by Dr. O. V. Darbishire of four species of *Laminaria ;* and Miss Ida M. Roper, F.L.S., reported on the year's growth of *Spartina Townsendi* at Clevedon.

THE 472nd GENERAL MEETING.

December 4th, 1918.

"The Octopus in Science, Literature and Art," by Dr. W. Evans Hoyle, M.A.

(*Director of the National Museum of Wales*).

The outward form of the octopus with its bag-like body and fixed protruding eyes may not be attractive, but the graceful movements of its four pairs of arms serve to redeem it ; whilst its power to adapt its whole colouration to its surroundings adds special interest. Both divisions of the family possess this power by changes of the pigments in cells in the skin, and they also agree in having air suckers for holding their prey, in using the arms for locomotion over the sea bottom and in the sea, and for a quicker backward movement by a current of water expelled from a special funnel within the mantle, after suction inwards over the air gills. Both likewise have boney parrot-like mandibles and can throw out a black liquid to hide their movements from enemies. The species of the argonauts secrete the beautiful shell for carrying about their eggs by means of a special adaptation of one pair of arms, and the pearly argonaut forms its coiled shell by adding each year a new and larger compartment till its final and largest one, in which it spends its mature life.

The octopus and nautilus figure in literary descriptions as terrible monsters and dainty beauties respectively, wanting, however, in actual facts, whilst in Art carvings more correctly, starting with early Cretan and Greek examples to the many grotesque applications in modern Japanese work.

PRESIDENTIAL ADDRESS.

By George C. Griffiths, F.E.S.

"Insects: Their Lore and Legend."

It may interest you in the first place to hear when the word "Insect" was first introduced into the English language. It first occurs in a translation into English of Pliny's Natural History, published in 1601 by Philemon Holland, who defines Insects as "little vermine or small creatures which have (as it were) a cut or division between their heads and bodies, as pismires, flies, grasshoppers, under which are comprehended earthworms, caterpillers, &c." You will observe that this quaint definition is more comprehensive than our present acceptation of the term, which regards the earthworms as belonging to a separate Order.

Now in searching the ample stores of Ancient and Modern Literature for references to the Insect world, we must not be surprised to find these far less numerous than those to higher groups, such as the Mammalia and the Birds. These, either by their commanding presence, or beauty and grace of form, or the sweet notes of the songsters of the woodland, have from the earliest times drawn the notice and admiration of the classical writer, or fired the imagination of the poet.

But although this is so for the most part, yet certain of the Insects have, either from their vast abundance, or by reason of some striking characteristic, useful or noxious, impressed their presence on bard and seer, and have made their mark on the literature of all time. Others again, have been regarded with veneration or even as objects of worship. Conspicuous among these is the Sacred Beetle, *Scarabaeus sacer*, so frequently reproduced in Egyptian picture-writing and sculpture, in the stone-carved Scarabs found in mummy-cases, or as a head-ornament in the representations of the god Ptah. The Beetle was called Kheper, and Prof. Flinders Petrie says it was regarded as an emblem of the Creator, Khepura, the Father of the Gods. Hence this insect and four or five other closely allied species living in the same region, were regarded from very early times as symbolic of being or existence. It appears sometimes with outstretched wings, or with a ram's head and horns, as the vivifying soul.

An insignificant little British Beetle, the Death-watch, *Anobium tessellatum*, has often been the subject of dread to the superstitious, and by its association with the latter days of William III. was brought for a time into notoriety. Swinton records that about the time of the King's fall from Sir John Fenwick's sorrel pony in the Home Park, much was said of the "ticking" of the Death-watch beetles in the Royal residence, and the Philosophical Transactions of the Royal Society were occupied by long papers from the savants

of the day, Allen, Dereham, and Stackhouse. These observers carried out an examination of the beetles, and agreed that the mysterious and ominous ticking was but the call of the amorous insect to its mate, and her feebler reply. Stackhouse declares that the sedge of a chair, where one was beating, was depressed "for about the compass of a silver penny."

An insect frequently represented in Egyptian hieroglyphic sculpture was the bee, known by the name of Khet, the meaning of which in their picture-writing is either the Northern hemisphere or Lower Egypt. The form of the insect as pictured, however, rather suggests a wasp in an aggressive or threatening attitude. To this day, I believe the Egyptian rock-sculptures are sometimes occupied by the wild bees for their nests. The Venerable Bede speaks of Ireland as "an island rich with milk and honey," on account of the number of bees found there in his day, the eighth century, A.D. In Coverdale's translation of the Book of Ecclesiasticus, chap. xi., 3, we are quaintly told "The Bey is but a small beast amonge the foules, yet is hir frute exceeding swete." In Heraldry the bee frequently appears in armorial bearings. Arkwright, the inventor of the "spinning jenny," and Sir Robert Peel, both bore bees in their coats of arms, and from the discovery of gold bees in the tomb of Childeric, Napoleon Buonaparte took the idea of covering his mantle with bees, and adopting the insect as the badge of his family. Keats speaks of the "yellow girted bees" and the "bee bustling down in the bluebells," and Tennyson sings of the "murmur of innumerable bees," a beautiful line, which at once brings up in our minds the memory of a hot summer's day on a clover-decked hillside.

Perhaps no insect received more attention from the Greek and Roman writers than the Cicada or Tettix, although in many references the insect appears to have been confused with species of crickets or grasshoppers, which also make a stridulous noise, though this is produced in a quite different manner from that of the Cicadæ. Probably the first mention of the Cicada occurs in Homer (Iliad, Book 3), in which certain Greek chieftains of advancing years are compared to the Tettix. We quote Lord Derby's translation—

"Sage chiefs exempt from war, but in discourse abundant,
As the cricket on high,
From the topmost branch of forest trees sends forth
His delicate music."

Of all insects which infest hot countries the most dreaded and most terrible are the Locusts, by reason of their countless numbers, their size, their migratory habits, and the rapacity with which they devour every living plant in their resistless march. Hence the historical and prophetic books of the Old Testament abound in references to the locust; the species referred to in Exodus as descending in its swarms upon the land of Egypt, was probably the

Acridium peregrinum, which inhabits the Northern regions of Africa, and the coasts of the Red Sea. The palmerworm, locust, cankerworm and caterpillar, mentioned by the Prophet Joel, were probably four different kinds of locusts or locusts in different stages of growth. The bald locust, named in Leviticus among the kinds of "winged creeping things that go upon all four, which have legs above their feet to leap withal upon the earth," and which might lawfully be eaten by the Israelites, was probably one of the species of Truxalis, which are remarkable for their long hard heads. As to the immense numbers of the locusts, the Arabs, quoted by Bochart, make a locust say to Mahomet "We are the army of the Great God ; we produce 99 eggs ; if the hundred were completed, we should consume the whole earth and all that is in it."

Southey, in "Thalaba the Destroyer," compares the marks on the locust's "yellow circled front with lines mysterious veined" to Arabic letters of cryptic meaning. In America, the migratory species of locust which has frequently done great damage in the Rocky Mountains region and Manitoba is *Caloptenus spretus* and the cricket which makes the woods vocal is *Cyrtophyllum concavum*, the Katydid.

Oliver Wendell Holmes, in describing the quiet of the New England Saturday evenings which ushered in the Puritan Sabbath, says that in his boyhood the music of the evening crickets seemed peculiar to Saturday evenings.

The very singular shape and attitudes of the Mantis have at all times attracted much attention. The name "Mantis" is of Greek origin, and Westwood tells us is employed in one of the Idylls of Theocritus to designate a thin young girl, with slender elongated arms. They are found on plants and trees, and have a habit of sitting motionless for hours together with the thorax raised and the long fore legs held up like a pair of arms, ready to seize upon any insect which may unwarily approach them. A species found in South Africa, we are informed by Sparrmann, is worshipped by the Hottentots as a tutelary deity ; and if it chance to alight on any person, he is at once considered to be a saint. The Turks and other nations also consider the strange attitude of the Mantis as suggestive of an act of devotion, and the creature has thus been called Prie-Dieu, and specific names of *religiosa, sancta* and *oratoria* have been bestowed by Naturalists on various forms.

Many of the Mantidæ are beautifully coloured in resemblance to leaves and flowers, but the purpose of this is not to protect the insect itself, but to enable it to attack the unsuspecting prey which are attracted by the flowers of the plant on which it has settled. Annandale, in his account of the Insects of the "Skeat Expedition" (P.Z.S., 1900) describes and figures a beautiful and rare example of this—*Hymenopus bicornis*, found on a plant of *Melastoma polyanthium* in Siam. At first sight it appeared to him that one of the

flowers was slowly swaying from side to side, and it was not for several seconds that he realized that it was not a flower at all, but an insect. Sir Charles Dilke states that a small Mantis found in Java resembles a pink orchid, and Dr. Anderson exhibited living immature specimens of *Gongylus gongyloides* before the Asiatic Society of Bengal in 1877, which on the ventral surface were found to possess in coloration and markings a strong similitude to a flower. This species, one of the most singularly shaped in this grotesque group, though known to Aldrovandus, a century-and-a-half before the appearance of the Systema Naturæ of Linnæus, had always been described and figured in various works from dried and faded specimens, hence the floral resemblance had not been previously detected.

China, Java, and other parts of Asia produce a number of species of Lantern-flies, of which *Hotinus candelaria* from India and China and *H. subocellatus* from Hongkong are some of the most striking, and here again travellers vary diametrically as to whether they are luminous or not. C. F. Holder, in Harper's Magazine, 1883, gives a woodcut of a shrub brilliantly alight with dots of living fire, and Wood states (Insects Abroad, p. 736) that a General in Hongkong saw a number of boys throwing stones at an object on a wall, which, according to his account, shone like a star. This proved on examination to be *H. subocellatus.* Westwood tells us that at one time there was a Chinese Edict forbidding young ladies to keep lantern flies. Annandale, in the paper already quoted (P.Z.S., 1900, p. 867) gives a very different explanation of the purpose of the very prominent proboscis or nose of these insects, which has been the supposed seat of their luminosity. He says that he noticed a specimen of *Hotinus spinolæ* seated on the trunk of a Durian tree, and attempted to catch it in his hand. The insect drew in its legs towards its body, and pressed its claws firmly against the bark, until his hand was almost upon it. Then it lowered its head with great rapidity, flew up into the air without spreading its wings, and alighted on the roof of a house 6 feet behind the tree, and considerably higher than the place from which it started. On examining the insect after death in the cyanide bottle, he found a crease or indentation across the middle of the nose, and that the chitin was flexible at that one point. He also found that if the tip of the nose and the dorsal surface of the abdomen were pressed together between the finger and thumb, and then suddenly released, the insect would not fall straight to the ground but would be propelled for some distance through the air. Annandale adds that he has examined many specimens of Fulgoridæ in the Hope Collection, Oxford, and has found the same crease in the noses of sixteen species, but, of course, it is difficult to trace in dried specimens, and impossible to experiment as to the elasticity of the organ. He intimates that it is probable that the bulbous nose of the American Fulgora may have the same purpose ; certainly it has a deep hollow across

it, which may correspond to the crease in *Hotinus*. Whether, therefore, the creatures are luminous or not, it seems that their grotesque nasal appendages have a very important use.

The great humming and stinging Tabanid flies, which often make our visits to the New Forest and other woodlands a pain rather than a pleasure, are known in old English literature under the various names of Horse-flies, Breeze-flies, Dun-flies, Clegs, Stouts, Brimseys, Brimps and Gad-flies ; in Kent the species of *Haematapota* are still called Brimps, a word probably derived from the Norse, meaning a roar, or buzz.

The ancients frequently represented Psyche by a butterfly, and according to Thomas Brown the Fable of Psyche and Eros, so beloved by poets, may be the invention of Apuleius. It was the capture of a butterfly, from which to paint the wing of a sylph, which led Thomas Stothard, R.A., to study Entomology. His fellow artist, Fuseli, was also a collector of Lepidoptera, as at the present time is Dollman, one of the most popular painters of the Great War. It may also be of interest to note that Charles Darwin actively collected Insects, and Coleoptera in particular, during the voyage of the " Beagle " between 1832 and 1836, and that many of the South American beetles then acquired, and now in the hands of the British Museum, are only in this present month being described by Mr. G. C. Champion in the Ann. and Mag. of N.H. and the Ent. Mo. Mag.

We can also claim as an Entomologist the poet Crabbe, who refers in his poem " The Borough," to his friend the Weaver and his captures of butterflies. The scholarly Gray also studied the insect tribes, and turned the characteristics of the Linnæan Orders into Latin hexameters, the MS. of which is still preserved in his interleaved copy of the "Systema Naturæ." These verses are quoted in Kirby and Spence's " Introduction to Entomology."

Mouffet, referring to that household pest the common Clothes-moth, says that he believes the Ancients possessed an effectual method of preserving stuffs from the attacks of moths, because the robes of Servius Tullius were preserved in Rome up to the death of Sejanus, a period of more than 500 years.

But our time is gone ; we are unable to-night to obey the admonition of the Wise King—" Go to the ant ! " or visit many other notable creatures, but I trust our excursion through some of the by-paths of Entomology may have been of interest to you.

The Charophytes.

By Cecil Sandwith.

(Read 7th November, 1911.

Professor Babington places the Characeae at the end of his Manual of Botany, with the following reservation :—"The position of this order is very doubtful." And in face of the fact that the Charas are not flowering plants, it may be wise to go back to the beginning, and consider how they came to be included—as they are now very generally included—in works, and County Floras, dealing more particularly with Phanerogams. The name *Chara* was first used for these plants in 1719 by Vaillant.

The Greek word *Chara* expresses "joy" or "delight," but it had been used as the name of a star, and on account of the star-like appearance of the floating branchlets, the name may have been adapted to these water plants. It was in the year of the Battle of Waterloo that the Family name Characeæ was first used for the Group.

Linnæus, with true insight, at first considered these plants to be Algæ, and classed them as such, but later, he followed a mistaken idea with regard to the reproductive organs, and finally placed them with the Phanerogams. Other botanists have tried to find some connecting link between these plants and other water plants such as Myriophyllum, Ceratophyllum, or even the Frogbit. In the Journal of Botany for 1878 there are interesting papers by Mr. Alfred Bennett, Prof. Caruel, and Prof. Vines, all dealing more or less with the position of the Characeæ in the order of plants. Mr. Bennett, after much complicated discussion, suggests that the Charas are "An abnormal form of Muscineæ—of Cellular Cormophytes, aquatic in their habits, in which the formation of the non-sexual generation is altogether suppressed"! Prof. Caruel, on the other hand, struggles to prove the relationship of the Charas to the Phanerogams. Prof. Vines, in a paper on the pro-embryo of Charas in the same volume, weighs up the respective merits of the two ideas put forward by Bennett and Caruel :—

(1) That the Charas may be mosses, rendered abnormal by their aquatic habits ;

(2) That the Charas should be placed between the Vascular Cryptogams and the Flowering Plants ;

and he decides that although the Charas bear strong resemblances to the Mosses, yet in their composition and peculiar cortication they also resemble some of the Carposporæ, and therefore he considers them an intermediate group. He makes short shrift of the idea that they can be linked in any way to the Phanerogams.

The Charas are undoubtedly Algæ, as Linnæus first thought but they belong to no particular group of Algæ and are a higher form of development.

The Family of Characeæ includes several genera, but at present only three are known in the district embraced by the Flora of Bristol :—Chara, Nitella, Tolypella. Of these, representatives of Chara are by far the most numerous. They can easily be distinguished by the cortical covering, which is lacking in the Nitellas and Tolypellas ; by their stouter appearance, and stronger odour ; and also, on closer examination, by the persistent crown of 5 equal cells to the nucule. There are other differences, but these are particularly obvious. The Nitellas and Tolypellas resemble each other more closely, both having the stem transparent, and no stipulodes. They differ in the position of the fruit, and the division of the segments, and like so many other things in the world, when known, they are easy to distinguish.

Huxley has an interesting chapter in his Practical Biology on these plants, which he calls Stoneworts. He describes their development as " a sort of alternation of generation, though the alternating forms are not absolutely distinct from one another." This point Mr. Bennett evidently disagreed with in the article already mentioned, where, when speaking of the Charas as " abnormal aquatic mosses," he adds : " in which the formation of the non-sexual generation is altogether suppressed."

Pringsheim, in 1863, discovered the growth of the spore, and he writes that " the sprouting spore does not at once produce the perfect plant, but first a pro-embryo, etc.," (translated). And Prof. Vines explains this very clearly : " In certain cases the embryo produced by the spore differs more or less widely from the adult form, and does not directly develop into it, but bears it as a lateral outgrowth. This mode of embryogeny is indirect . . . . as in the Characeæ, where the oospore gives rise to an embryo of limited development upon which the adult sexual form arises as a lateral branch." This growth from the spore is illustrated by de Bary in his well-known figure of a very ungainly-looking Chara plant, arising from the irregular provisional verticil of a pro-embryo, attached to the oospore.

These spores are the ripe fruit of the Characeæ, and, when the autumn comes, may be found lying in the mud, or caught up in the general debris of the wayside ditch. After fertilization, the 5 spirally twisted cells, which wrap tightly round the " Mother " cell, become hard, and change to a dark brown or slaty grey colour, and the fruit, well-protected by its hard outer shell, rests, until the appointed time comes for germination. These resting spores are very minute, oval, or roundish, according to species, and always striate, marked with the slightly raised spiral lines of the enveloping cells.

These lines vary in number with different species, and are sometimes difficult to see owing to the calcareous substances with which the plants are often encrusted. It is interesting to note that *C. fragilis* is less subject to incrustation than many species, and is therefore better for examination, both with regard to the cortical cells, and also the fruit, of which latter I have sometimes been able to collect perfect examples. As the time approaches for germination, changes have been taking place under the hard outer shell of the oospore. The cell, which was so carefully protected by the enveloping tubes, becomes two by division ; a small cell near the apex of the nut ; and a large cell, filling the lower part, and stored with starch and fat for feeding the plants. The small cell contains protoplasmic matter, and grows until it splits the outer shell across, at the Crown, then it divides into two, and one cell growing upwards becomes the pro-embryo plant, while the other, growing downwards, forms the first root node. The pro-embryo is at first colourless, and grows up to a point, where, by division of cells, it seems to be putting out leaves ; but these are merely appendages, without form, and quite irregular, and only serve as the starting point, from which a cell arises which gives birth to the true Chara plant. The stem of the true plant is green from the first, and is composed of long cells, called internodes, which lengthen with the growing of the plant, but do not divide. These are partitioned off at intervals by smaller cells, which form the node, and divide, giving rise to the leaves and branchlets. Properly speaking, there are no leaves in a Chara plant. The so-called leaves are formed, like the stem, of internodes and nodes, but are limited in their growth. Botanists have become accustomed to speak of the branchlets as leaves, and so the name persists.

In the genus Chara, the stem and branchlets are covered with a Cortex (or bark) composed of cells which originate in the nodal system. As the stem elongates, these nodes vary in their position one above the other, each node diverging about half the space between the cells, so that the cortical cells, growing down to join those growing upwards from the node below, do not meet over the internode with any regularity, but overlap and "interdentate," giving the twisted spiral appearance to the stem which is so peculiar and interesting. This is particularly noticeable in *C. polyacantha*. The unconventional behaviour of the cortical cells in this species forms quite an interesting study. I have seen the stem so rugged and billowy that it might almost be compared to a storm at sea. *C. fragilis* is one of the best examples to study for perfect regularity. It is rather strange that the rule which governs the position of the stem nodes should not apply to those of the branchlets (or leaves). In the case of the leaves, the nodes are formed one above the other, and the cortical cells from above and below meet with regularity. Some authors speak of the slight twisting which may sometimes be noticed in the branchlets, and add that this is generally

in the opposite direction to that noticeable in the stem. This may have some connection with the protoplasmic streaming in the cells, which is, I think, invariably in the opposite direction to the streaming in the stem cells. Prof. Ewart, speaking of the Characeæ, in his excellent work on Protoplasmic Streaming in Plants, writes :—"That the spiral direction of streaming . . . . may be of biological utility is quite possible, just as may also be the spiral twisting of the cortical cells themselves, but teleological explanations afford no indication of casual relationship."

However this may be, there is food for reflection, when we consider, not only the spiral twisting of the cortical cells and the spiral direction of the protoplasmic streaming, but also the spiral of the enveloping cells, which form a covering for the spore, and the little spiral antherozoids which are shaped like tiny corkscrews.

It is necessary to know something about the cortical cells, for it is by studying these that botanists are able to classify their plants. The fully-developed cortex system consists of three cortical cells to each branchlet in the whorl, i.e., a central nodal cell, with its node and spine, and two lateral cells. It is only the main, or primary cortical cell, which develops nodes, and spines, and it is the position of this cell that the botanist observes when studying Charas.

Sometimes only one lateral cell is developed, as in our commonest Chara, *C. vulgaris*, which is placed in the class termed *Diplostichæ*, possessing two cortical cells to every branchlet in the whorl. *C. fragilis* is a good example of the fully-developed cortex, *Triplostichæ*. To each branchlet in the whorl there is a primary, and two lateral cortical cells.

We have one British Chara, which comes under the class *Haplostichæ*, *C. crinita* Wallr, also known as *C. canescens*. This plant develops no lateral cortical cells, and the primary cells with their spines are so close together that the stem has a very prickly appearance. From the same node which develops the cortex, spine cells appear beneath the whorls of leaves. These are called Stipulodes, and are only found in the cortex-covered Charas. The long transparent stems of the Nitellas and Tolypellas have no spines, and no stipulodes. The leaves, which are no leaves, but merely branchlets of limited growth, develop bracts, or rays, from their nodes. These all have to be taken into consideration when determining the species ; for they differ in number, size, and position, and some Charas develop no bracts on the outside of the leaf, whilst the development of others is only rudimentary, and these points are useful and definite in distinguishing specimens.

The reproductive organs are of two kinds, round red globules, Antheridia (male), and oval nucules, Oogonia (female). These are always borne on the leaves, or at the forking of the branchlets, and originate from the node. In its early stages the Antheridium

is almost transparent and of a pale green colour ; it is globular, but appears to be cut into four divisions in the centre. As time goes on the cells divide, and the whole appearance changes. The Antheridium becomes red or orange, and appears beautifully and symmetrically marked with a raised pattern. This is owing to the eight triangular shields, of which the outside is formed, four above and four below, shaped and fitted together with interlocking edges, so that they seem but one piece. Inside, and attached to each shield, is a cell called the Manubrium. The name suggests the idea of a handle, and these eight Manubria act in that capacity, bearing the round capitulum cells, to which are attached six smaller cells known as the secondary Capitula, from each of which proceed long filaments, two to four in number, and each divided into from 100 to 200 cells, which are partitioned off and contain protoplasmic matter. This substance does not long remain colourless or shapeless. Rapid changes take place amongst the little thread-like-bodies that are evolving themselves out of apparent nothingness in each cell, and when the Antheridium is ripe, the interlocking shields divide quite symmetrically, and about 20,000 to 40,000 little Antherozoids escape from their cells, and literally swarm in the water, looking like microscopic corkscrews, guided along by vibratile cilia, until by some curious power of attraction they are led to the open neck of the Oogonium, and swimming in, perform the work of fertilization. After this the Oospore sinks to rest, to await its further development.

Looking at one of these split globules, one realises that it would take something more than mere human ingenuity to fit together again the 265 parts of which it was composed, and re-fill it with the 40,000 lively little antherozoids that so lately made their escape.

There is little more to be said about the Oogonium, as its later stages have been described already. It is formed on the leaves, and is "the enlarged terminal cell of the leaflet which it represents" (Vines). By the formation and division of cells, there appears a terminal cell which is the spore, a cell which becomes the stalk, and a cell below which forms a node, and from which spring five spiral cells ; these grow round the spore cell, and coiling tightly, envelop it. These spiral cells lengthen and divide at last into smaller cells, forming what is known as the Corona, or Crown. In the genus Chara there is only one division, so that the Crown consists of five cells, but in the Nitellas the enveloping cells make two divisions, forming a crown of ten cells in two rows. The Characeæ increase and multiply largely in a vegetative manner, asexually.

It is interesting to examine them when the season is over, and the old stems and nodes have thickened, and filled with starch. One may grow these old plants, and watch new cells rising from

the old nodes, and the new plants growing out from the deformed brown joints.

C. aspera develops round or oval bulbils on the rootlets. I found these very numerous on plants growing under difficulties and making a struggle for existence, where apparently for some reason or other they could not, or did not, bear fruit.

Pringsheim has gone fully into the study of the two modes of asexual reproduction shown by the Charas :—

(1) The *gymnopodal,* or bare-foot branches. These are abnormal in their lower joints, sometimes having a defective cortex, and sometimes no cortex at all.

(2) *Embryonic branches,* which appear on the two-year-old nodes, and develop as the pro-embryo of the Chara plant develops from the spore, first with a colourless section, and then with an irregular verticil having the appearance of leaves. From which point, as in the case of the true pro-embryo, the new Chara plant arises as an embryonic branch.

There is one thing more of the deepest interest to be studied in these plants, but I can only touch upon it briefly. Those possessed of the seeing eye and the understanding heart, can fathom these mysteries for themselves. We all know that in certain plants protoplasmic streaming can be seen in the cells. In the long transparent stem tubes of the Nitellæ this can be seen very plainly. There is continual motion, and the small green chloroplastids, the little transport bearers, are carried swiftly along up the cell, from left to right in a spiral direction, and down again on the other side in regular order, bounded by a colourless spiral line, "the indifferent line," which seems to part the upgoing stream from that which returns. The chloroplastids have no active power of movement of their own. Their work is to construct organic matter out of the air, and water, by the help of the sun and their energy; and they are borne along by the streaming of the denser layers of protoplasm to distribute food to the growing plant. Prof. Ewart considers this continual streaming to be essential to the life of the plant, and that it is of great importance for rapid translocation; and Alex. Braun showed that the direction of streaming influenced the development of the lateral leaves and roots. These statements may be tested, for the Bristol district is rich in material. The commoner forms, *C. vulgaris* L., *C. fragilis* (Desv), and *C. delicatula* Braun, are frequently to be met with. And *C. hispida* L., *C. Hedwigii* Ag., and *C. polyacantha* Braun have also been found, the latter a rare and most interesting species. These plants thrive best in ponds or dykes, where the water is more or less stagnant. In one case *C. polyacantha* has chosen a situation which is positively putrid, and the wonder is that it can continue to exist there. No Nitella was known in the Bristol

district up to the year 1910, when Mr. Cedric Bucknall discovered *Nitella opaca* Ag. in three ponds on Yate Common, the only record being an old one in 1868 from a pond at Berkeley, mentioned in the Flora of Bristol.

The year 1917 was marked by the discovery of a new and distinct variety of the rare *N. mucronata* Miquel, var. *gracillima*, found by Miss Roper between Wickwar and Yate. This plant appeared to be confined to one small pond in an enclosure at that time ; but it is consistent with the vagaries of these fugitive plants to note that this one has changed its position each year since its discovery, seemingly abandoning the old ponds, or growing itself out, and starting its career again in a new pool some little distance off. In May, 1917, I was fortunate enough to find a new habitat for *N. opaca* Ag., and also to record the first Tolypella for the district, both in the neighbourhood of Yate. *Tolypella intricata* Leonh. still persists in a small way in the insignificant pool where it was first found, but in February, 1918, was discovered in some abundance by Messrs. White, Bucknall, and myself, growing with the already-known *N. opaca* in one of the ponds on Yate Common. This must have been quite two miles from the first station recorded. That these apparently fragile-looking plants can live through severe weather is proved by the fact that I have found the Yate plants bearing antheridia under thick ice, as on another occasion in Yorkshire I found *N. opaca* with antheridia in December and January in a frozen ditch. From personal observation I should assume that some of these plants are protandrous, and in the case of *N. opaca* that the male plant is more plentiful than the female form.

Since I gave my paper, several important discoveries have been made, and I have been asked to mention these. In November, 1918, I, with N. Y. Sandwith and Mr. T. H. Green, of Weston, Bath, examined the Canal near Bathampton, and found *Tolypella intricata* and *N. opaca* both growing there, very brittle and incrusted, but still distinguishable, though useless for herbarium specimens. In the following spring I gathered material which confirmed the records, which were new for the N. Somerset side of the Bristol district. More important still was the finding of *Nitella translucens* Ag., in June, 1919, by Miss Honor Perrycoste with N. Y. Sandwith and myself, growing abundantly in several deep pools left by peat diggers, in a lonely part of the turf moor between Ashcott Station and Glastonbury. These deserted holes are often full of water, and the Nitella was in splendid condition, literally shining, as its name suggests, with its pellucid stems and balls of golden fruit. *N. translucens* was not only a record for the Bristol district, but also for the entire County of Somerset, and it is satisfactory to note that within the last three years one Tolypella and two Nitellas have been added to the flora of N. Somerset, in addition to the valuable discoveries made in West Gloucestershire.

There is a question often asked: What use are these plants? Are they good for food? I do not think anyone would be tempted to eat a Chara. Its scent is its best protection from wholesale demolition. Hassall asks: What is the part of a Chara in the plan of the Universe? I do not remember his exact words, but it seemed to me that he felt the hand of the Creator and was looking for His purpose, realising that such perfection could not be purposeless. Prof. Reynolds, in his lecture on the formation of rocks, showed pieces formed from fossilized Algæ, and even now Mr. James Groves, one of the greatest living authorities on the Characeæ, is doing research work amongst fossil Charas found in the Purbeck beds. It may not be long before some of these problems are solved. In the meantime let us consider that these little Stoneworts are "doing their bit" towards the making of a New Earth. And we know—

> That nothing walks with aimless feet;
> That not one life shall be destroyed,
> Or cast as rubbish to the void,
> When God hath made the pile complete.
>
> *Tennyson.*

The Growth of the Dandelion Seedling.

By D. E. WATKINS.

(Department of Botany, University of Bristol).

BEFORE the growth of the dandelion seedling can be quite understood a short description of its germination as observed when grown on damp blotting paper is desirable.

The dandelion fruit is small. As regards shape, it is flattened and broader at the end to which the parachute is attached than at the other. The pericarp has two very deep longitudinal grooves running down it and several smaller ones. On the ridges between the grooves small hooks are arranged in rows with the hook pointing downwards. These hooks are especially numerous at the top of the fruit and get smaller and less in number towards the bottom. Their use may be either to help in the seed scattering, or to fix the seed in the soil when once it has been scattered.

After two or three days on damp blotting paper the fruits begin to show visible signs of germination. The pericarp has begun to open at the base and split up the longitudinal grooves for a short distance. The small yellow root then appears through the hole, and as it grows, the fruit wall splits more and more along the deeper grooves. In a very short time the root cap with the fine root hairs behind it, can be seen. The cotyledons begin to swell, and in doing so, split the fruit wall still more, until in another two days, the yellowish cotyledons have freed themselves of the coat altogether. The coat remains on the tips of the cotyledons in most cases until they have become accustomed to the light, and during this time they change in colour to a bright green.

After this, the root and the cotyledons elongate at a fair rate, and each cotyledon gradually becomes differentiated into a definite blade and petiole, the former with a very indefinite mid-rib. The bud for the first foliage leaf is formed between their petioles.

Very few seedlings live beyond this stage on the blotting paper, for apart from not being able to obtain sufficient nourishment, the conditions are very unnatural.

The fruits planted in soil germinated, and their cotyledons appeared above the soil after two weeks. At first they were bent right over in the form of a loop above the soil. As they grew accustomed to the light, they became green, grew upright, and then opened out. Some seedlings did not come up in exactly this way, but pushed their cotyledons above the soil in an upright position and retained the fruit wall over them till they were better able to stand the light.

The seedling itself is very characteristic. It is quite small at first, varying in height from 1 cm. to $1\frac{1}{2}$ cms. It consists of a hypocotyl coming from the ground, which is quite short in com-

parison with the petioles of the cotyledons. The hypocotyl swells out slightly at the top, and from the swelling the cotyledons grow out by their two long petioles which separate at an angle, from 30° to 40°. The hypocotyl and the petioles are a very pale green in comparison with the blades of the cotyledons, which are bright green and glossy, and have an indistinct mid-rib. The shape of the cotyledons varies somewhat, but generally speaking, is broadly oval, rounded at the apex, entire, and narrowed at the base into the petiole. They turn back in an horizontal position at the top of the petioles. At the base of the hypocotyl is a slight twist where the hypocotyl passes into the main root, which tapers downwards and is very long in comparison with the rest of the plant.

The first foliage leaf is produced from the end bud between the cotyledons. This at first looks more like a third cotyledonary leaf, but as development takes place, the mid-rib and net-veining become distinct, the shape characteristic, and the margin serrated. The further development of the seedlings is interesting because of their behaviour in firm and loose soils.

In the first case, the fruits were sown in very rough, loose soil and no care was taken with the sowing. After seven weeks (in October - November) about six of the plants had grown to a good size, and most of them had reached the stage when the two cotyledons and two foliage leaves had developed. The hypocotyl was 1 cm. above soil and in consequence the whole plant was loose and not at all firmly established in the soil. During this time the leaves grew very slowly indeed, and after a week no fresh leaves had developed, and the others had grown but very little. This point stood out above all others because beforehand the plants had been growing exceedingly quickly. At the end of another two weeks one new leaf had developed and the hypocotyl appeared to be wrinkling a little (see Fig. *I.a*). One of the specimens was pulled up, and it was found that the hypocotyl below the soil had also wrinkled up considerably.

At the end of another week, the hypocotyl had wrinkled down its whole length, and the part of it above ground was decidedly shorter (Fig. *I.b*). Also, during this week, the plant had been growing much more quickly. By the end of a fortnight the plant had been pulled down completely into the soil. No hypocotyl appeared above ground and the leaves looked to be growing straight up from the soil (Fig. *I.d*). In a few more days the plant had grown tremendously but was still being pulled deeper into the rough soil. This continued till the bases of the older leaves and the whole of the young bud were below soil (Fig. *I. g*). By this time the plant had established itself firmly and was able to give up its energy for growth.

Several series of plants were tried in this way, and in every case the same thing happened to those in rough soil. In every case the hypocotyl which had disappeared from above the soil was

Fig. 1.

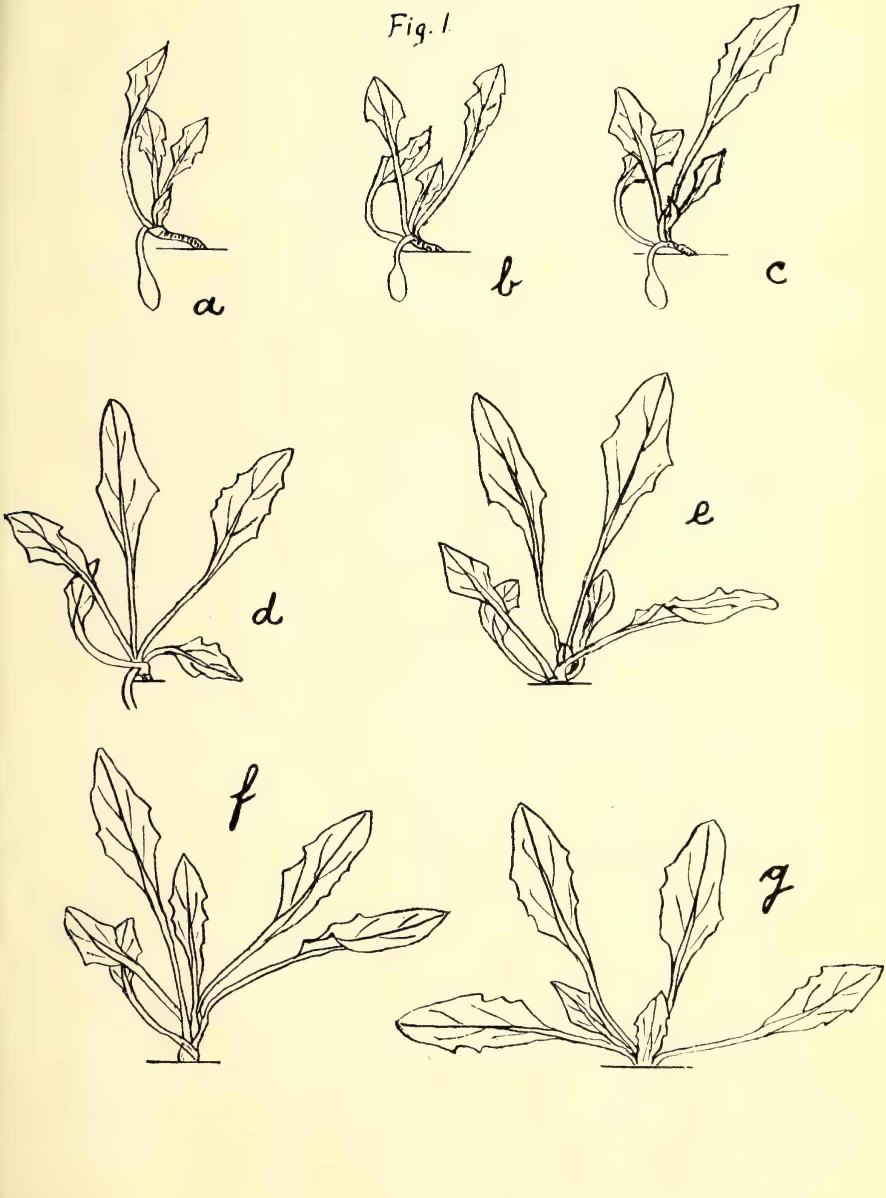
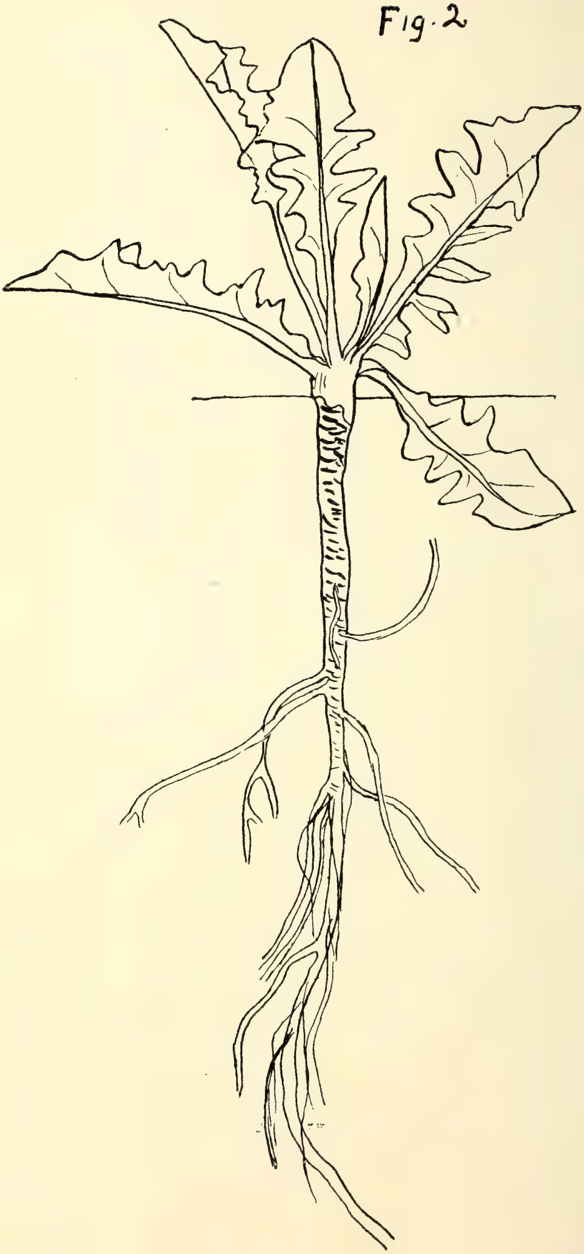


Fig. 2



examined and found to be in a very wrinkled condition below the soil.

A longitudinal section was taken of the hypocotyl and the top of the root. The wrinkling of the outer layers of the hypocotyl could be seen, but beyond the base of the hypocotyl there was no wrinkling in the root. It must be supposed that the inner layers of the hypocotyl contract. The roots are fixed firmly in the soil so do not give, and in consequence the contraction affects the shoot and pulls it down. The contraction of the inner layers of course causes the wrinkling of the outer layers.

Other fruits were planted to try to obtain similar results, but care was taken with the sowing, and the seeds were placed on firm soil and covered with a firm layer. They appeared above ground after the same time as the others, but the hypocotyls of the majority of them did not grow to any distance above the soil, and consequently, most of them were firmly established from the beginning. They certainly grew more quickly than the rough soil seedlings, but this may have been partly due to the fact that they were sown in the warmer month of April. A few of these same seedlings, however, were not firmly established, they probably being of a different species as the conditions were the same for both. After 2 weeks the hypocotyls of these appeared to wrinkle, and they were drawn firmly into the ground after another week.

The hypocotyls of several of the plants which had been firmly established from the beginning were examined and were found to be quite smooth and absolutely devoid of wrinkles as no contraction was needed in these cases.

Some older dandelion plants were dug up and examined, to see the appearance of the hypocotyl and roots. In about twelve specimens which were examined, ten showed the deep wrinkling of the hypocotyl as in Fig. *II.*, and two specimens only had smooth hypocotyls. Most of the plants were fixed firmly in the soil, but a few that were not firm had wrinkled hypocotyls $1\frac{1}{2}$ ins. to 2 ins. above the soil. When these plants were dug up, it was found that the main root was broken off at the base of the hypocotyl. Because of this injury, the pulling force exerted by the hypocotyl was probably of little use, as the root was not there to keep the bottom of the plant firm, and there was nothing for it to pull against.

Some still older plants from a rockery were examined where conditions were very adverse, and the roots of these were very long indeed and thick, and the tops of the roots and the hypocotyls were strongly marked with wrinkling.

In conclusion, a summary of this investigation can be made. From the above experiments it seems that dandelion fruits scattered in rough places as they often are, can germinate and grow to a certain extent, but usually they are not at all firm in the ground.

In consequence, growth becomes very slow and the plant devotes all its energy to establishing itself firmly in the soil. The inner cells of the hypocotyl contract, causing a wrinkling up of the outer layers and the shoot is pulled firmly into the ground, after which, it can devote its energy to the growth of its leaves and roots.

The contraction of the root, and the subsequent drawing down of the very short above-ground stem of the dandelion plant, continues after the seedling stage has been passed. It is due to this that the leaves and flower stalks of the current year always arise just on the surface of the soil.

The above investigation was carried out at the suggestion of Professor Darbishire, in the Botany Department of the University of Bristol.

EXPLANATION OF FIGURES.

Fig. *I.a* to *Ig*. The settling down of a seedling growing in rough soil :— *a*, after 14 weeks ; *b*, after 15 weeks ; *c*, after 16 weeks ; *d-g*, subsequent stages.

Fig. *II*. A mature plant which has been grown in rough soil, and has been pulled well into the ground.

Bristol Botany in 1918.

By Jas. W. White, F.L.S.

NOTWITHSTANDING the pressure of other occupations and restrictions on travelling some good work was done during the year by industrious members of the Society and outlying correspondents. Limitation of space forbids the publication of every note ; those of most interest, therefore, have been selected.

Ranunculus parviflorus L. Clevedon Court Wood ; *H. S. Thompson.*

Fumaria pallidiflora Jord. Burnham ; *Watson* in *Journ. Bot.* 1917, p. 180. Corner of churchyard, Axbridge. The Axbridge roadside plant (*Fl. Brist.* 139)—and the churchyard colony appears to be the same—has been determined as his var. *Babingtonii* by Mr. H. W. Pugsley. *F. officinalis* L., var. *Wirtgeni* Haussk. Knowle, Somerset, 1881 (as *F. officinalis*) ; *W. H. Painter* in *Herb. Brit. Mus.* Cornfield near Keynsham, S. May, 1918 ; *Miss Roper.*

Viola.—Notes by Miss Roper, save where otherwise specified.

V. palustris L. Emborough Grove and Eaker Hill Wood ; *B. W. Tucker.* The Watchetts, near Wells. In two places on the Ashcott peat moor ; *H. S. Thompson.* Shapwick Moor. The rare form *alba* is on Mendip ; *J.W.W.* *V. epipsila* Led., var. *glabrescens.* Priddy-on-Mendip, 1897 (as *palustris*) ; *J.W.W.* Still there. *V. odorata*, var. *præcox,* Gaunts Earthcott, G. Hallatrow, S. *V. hirta* L., var. *propera,* Backwell Hill, S. *V. hirta* × *odorata,* West Hill, Wraxall. Lyncomb Hill, Sandford. Barley Wood, Wrington. Asham Woods, Frome. × *V. sepincola,* Cadbury Camp. × *V. collina,* Black Rock, Cheddar.

Cardamine pratensis L. With double flowers at Bishopsworth, 1880 (*Fl. Brist.* 146). Still persists in four meadows. But observation shows apparently that the change of stamens into petals is due to gall mites affecting the young buds. The condition, therefore is not necessarily reproduced year by year in the same plant. At Pipley Bottom, North Stoke, fine double flowers were blooming a fortnight later than single ones ; *F. Samson.*

Lychnis Flos-cuculi L. With white flowers. Berwick Wood, Hallen, G. ; *H. J. Gibbons.* Ashcott Moor ; *Miss Roper.*

Cerastium pumilum Curt. Banwell Hill ; *Miss Roper.*

Geranium sanguineum L. Still in Ebbor Gorge ; *Miss Roper.*

Medicago sativa L. In a recent number of *The Garden,* Mr. H. S. Thompson has a paper on Lucerne and its colour-forms. He

mentions that at Burnham the tints vary from pale yellow to black-violet, and he claims very little importance for such colour variations, especially in plants with normally blue, purple or red flowers.

Trifolium medium L. The Perch, Axbridge ; *Miss Roper.*

Vicia lathyroides L. Above Charlcombe Bay, west of Portishead ; *Miss Roper.*

Ervum nigricans M.B., *Cicer arietinum* L., *Lathyrus sativus* L. Aliens on the Eastville tips ; *Miss Roper.*

Spiræa Filipendula L. Old Down, Tockington ; *Miss Roper.* Rare in the Gloucestershire division of our district.

Fragaria moschata Duch. Woodmancote, Dursley ; *Miss Roper.* Confirms St. Brody's record dated 1868.

Rubus sulcatus Vest. Wood, Walton Moor ; *Miss Roper. R. Godroni,* var. *robustus,* P. J. Muell. Rowberrow Bottom ; *Id. R. anglosaxonicus,* var. *setulosus* Rogers. By the Avon, G. ; *Rev. H. J. Riddelsdell. R. Drejeri,* var. *Leyanus* Rogers. Sea Mills and Cromhall, G. ; *Id.* Worle Hill, S. ; *Rev. A. Ley.* Shapwick Moor ; *H. S. Thompson. R. radula* var., *echinatoides* Rogers. Stinchcombe Hill, G. ; *Rev. H. J. Riddelsdell. R. Balfourianus* Blox. Hedge on Tockington Hill, G. ; *Miss Roper.* Westridge Wood, Wotton-under-Edge ; *Rev. H. J. Riddelsdell.*

Bupleurum tenuissimum L. Land Yeo estuary, Clevedon ; *Rev. E. Ellman.*

Sambucus nigra L. A tree with yellow fruit on an ancient track above Weston-in-Gordano ; *Miss Winsome Bartlett.*

Dipsacus pilosus L. Along 100 yards of a hedge on Yate Lower Common ; *J. W. Haines.*

Onopordon Acanthium L. On Breakheart Hill, Dursley, in some quantity ; *C. E. L. Gardner.*

Inula Helenium L. Corner of field between Congresbury and Churchill ; *Mrs. Sandwith.*

Hieracium maculatum Sm. Holcombe, S., just within the district ; *Miss Roper. H. rubiginosum* F. J. Hanbury. A second locality at Cheddar, on heights opposite the Black Rock ; *Id.*

Artemisia Tournefortiana Rchb. An Asian introduction. Several plants in a cabbage-patch on Wapping Wharf, Bristol Harbour. On rubbish at St. Anne's, Brislington. Fowl-run near Kingswood, G ; *Miss Roper.* Garden weed at Failand ; *D. Williams.* Occurred at Didcot, 1895 (*Druce*) ; and at Ledbury, 1907 and subsequently (*Bickham*). Of peculiar habit—erect, slender, unbranched and

tall, up to four feet in height. In Koch's *Synopsis* this species is described as being glandular-viscid, but our plants are not so and it has been suggested that they may be *A. biennis* Willd. from North America. *A. scoparia* W. & K. Railway siding, Wapping Wharf. *Lepachys* (*Rudbeckia*) *columnaris*, the Prairie Cone-flower of the western plains, U.S.A. Determined at the Missouri Botanic Garden. Site of mule camp near Long Ashton, S.; *Miss Roper.*

Vaccinium Myrtillus L. Three distinct patches still exist and produce fruit in Leigh Woods; *Miss Roper.* Windmill Hill, between Failand and Portbury; *Id.* Further consideration has led me to believe that the Bilberry may be native on the Court Hill, Clevedon. It is thought to have disappeared at Durbin's Batch.

Atropa Belladonna L. A number of plants have been reported from fresh spots in Leigh Woods.

Digitalis purpurea L. In the *Journal of Genetics* for May, 1918, Miss Saunders has established the fact, apparently not hitherto recognized, that the Common Foxglove shows itself, both in Britain and on the Continent, under two distinct forms; the one, usually looked upon as the type, with stems densely hairy throughout and thus grey-tinted = *D. purpurea—pubescens*; the other = *D. purpurea—nudicaulis* with bright green stems smooth and polished up to near the flower-spike where hairiness begins. It is stated further that the latter form is more frequent and of wider distribution than the other. This, however, is not yet shown to be the case in the Bristol district, where the hundreds of plants examined were practically all hoary, the form *nudicaulis* being met with chiefly in gardens.

Blitum virgatum L. Casual at Queen Charlton, S.; *Miss Roper.*

Chenopodium ficifolium Sm. Grassy roadside waste amid nettles between Ken and Kingston Seymour; *Rev. E. Ellman.* *C. polyspermum* L. Chapel Allerton, Wedmore; *Mrs. Sandwith.* Oatfield near Yate Court, G.; *Miss Roper.* On rubbish at Eastville with *C. hybridum* L.; *Id.*

Euphorbia platyphyllos L. Cornfield on Wedmore; *Rev. E. Ellman.*

Epipactis atroviridis W. R. Linton. Grayfield Wood, Hallatrow; *Miss Roper* and *R. V. Sherring.*

Cephalanthera pallens Rich. Westridge Wood, Wotton-under-Edge, sparingly; *Miss Roper.* Still in woods near Hinton Abbey, whence it was recorded by Sole in 1805; *Id.*

Cladium jamaicense Crantz. Walton Moor, near Clevedon, extending about 100 yards along a ditch on the southern side of the moor; *Miss Roper.* In view of the amount of botanical work

that has been done in the Walton Valley during many years it is astonishing that so fine a sedge should have escaped observation until this summer.

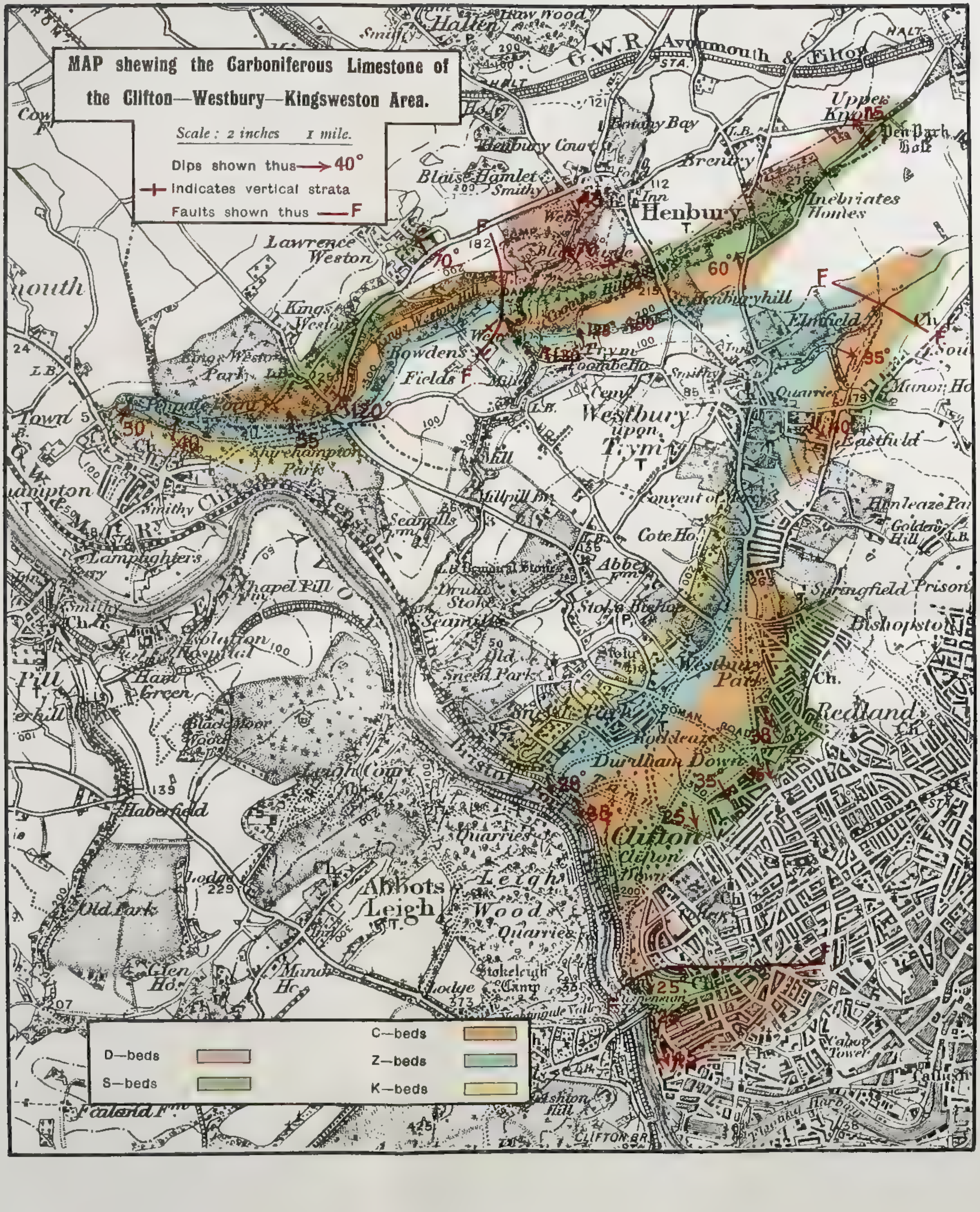
Eleocharis acicularis R. & S. Still on the canal bank near Bath, where it was discovered by Mr. D. Fry in 1893.

Phleum asperum Jacq. (*P. paniculatum* Huds.) "Waste ground, Bristol"; *Mrs. Sandwith.* Fowl-run, near Kingswood, G; *Miss Roper.*

Avena strigosa Schreb. One plant on a waste heap at Eastville, G.; *Miss Roper.* An introduced plant, probably not a native of Britain, now observed in this district for the first time.

Polystichum aculeatum Roth, var. *lonchitidioides.* Asham Woods, S. *fide* A. Bennett; *Miss Roper.*

Nitella intricata Braun. Appeared in another pond near Yate at the beginning of February. Observed in the canal at Bath, together with *N. opaca* Ag. by Mrs. Sandwith in November.


MAP shewing the Carboniferous Limestone of the Clifton—Westbury—Kingsweston Area.
Scale: 2 inches 1 mile.
Dips shown thus 40°
Indicates vertical strata
Faults shown thus F
D—beds
S—beds
C—beds
Z—beds
K—beds

The Carboniferous Limestone of the Clifton—Westbury—King's Weston Ridge.

By SIDNEY H. REYNOLDS, M.A., Sc.D., Professor of Geology in the University of Bristol.

CONTENTS :

I. INTRODUCTION.

(a) *Geological Structure.*

The rocks described constitute the eastern portion of the faulted and much denuded periclinal uplift, the remainder of which is formed by the Clifton-Clevedon ridge and the Clevedon-Portishead ridge. The mouth of the Avon and its associated flats are responsible for the wide gap in the limestone between Penpole Point and Portishead. The area differs from the neighbouring pericline of Broadfield Down in having been greatly denuded in pre-Triassic time, so that the core of the anticline consists of Old Red Sandstone largely concealed under Triassic rocks, and forming a lowland surrounded by the horseshoe-shaped outcrop of the Carboniferous Limestone. Owing to the overstep of the Trias the lower beds of the Carboniferous Limestone series are concealed throughout a considerable part of the outcrop along the inner margin of the horseshoe, while along its outer margin between Redland and Brentry the Lias overlaps the Trias and rests directly on the Carboniferous Limestone. Owing in part to the varying amount of overstep and in part to variation in dip, the width of outcrop of the Carboniferous Limestone varies from its maximum of about a mile near the Avon at Durdham Down, to about 300 yards at a point near the top of Westbury Hill. Much of the area is built over, which adds to the difficulties of mapping. On the other hand the recent great development of allotment gardening has increased the number of exposures.

(b) *Previous Work.*

The only publication containing more than the briefest allusion to the rocks which form the subject of this paper is Vaughan's classical paper "On the Palæontological sequence in the Carboniferous Limestone of the Bristol Area" ; all references under "Vaughan" are to this paper. The rocks are alluded to under the names and symbols adopted by Vaughan.

II. Disturbances Affecting the Area.

The northern limb of the horseshoe forms a continuation of the line of faulting which extends from Clevedon towards Clapton-in-Gordano. It shows some interesting evidence of disturbance which here takes the form of folding rather than faulting, the facts being as follows. At Penpole Point the rocks have the normal northerly dip at an angle of about 40°, but as they are followed eastwards the dip increases, till at the Iron Bridge the rocks are vertical, and further to the north-east are inverted and dip at 120° (*i.e.*, have a south-south-easterly dip of 60°). A similar south-south-easterly dip is seen to the north of Combe Dingle, while near Combe Farm there is evidence of sharp folding. In the old quarry 350 yards south-east of the Pavilion on Combe Down, and in the big quarry at the eastern end of the Down the rocks are vertical, or have a normal (N.N.W.) dip at an angle of about 80°. At Brentry the dip is still normal, and not quite so high as in the last-mentioned quarry, but further to the east the dip again increases, the rocks in the old quarry at Brentry Farm being vertical, while in the last set of exposures, those at Upper Knole the rocks in the old disused quarry north of the road are considerably overfolded, dipping at 115° (*i.e.*, having a reversed dip of 65°). Those in the northern part of the big quarry south of the road are slightly overfolded, while those in the main part of the quarry are vertical.

III. Description of the Exposures.

(1) *The Cleistopora* (K) *Beds.*

No permanent exposures of this horizon are seen in the area except in the immediate neighbourhood of the Avon and north of Combe Dingle. In the wooded slopes leading down from Sneyd Park to the river there are several exposures of the K-beds. Thus the Bryozoa-bed is finely exposed along the eastern boundary of the grounds of Cook's Folly, where also something is seen of the Km-beds. Exposures of K2 are seen by a path leading from the grounds of Avon Wood towards Press' Quarry.

In the 1-inch Geological Survey Map the K-beds are shown (as Lower Limestone shale) extending north-eastward from the Avon for rather over a mile, *i.e.*, till near the top of Parry's Lane, where they are overlapped by the Dolomitic Conglomerate. I have seen no exposures along this line except a temporary one of the Bryozoa-bed made in 1919 near the north end of Julian road. The K-beds are not shown in the Survey Map from near the top of Parry's Lane for a distance along the outcrop of about two miles, *i.e.*, till the neighbourhood of Combe Dingle is reached. The K-beds are not however concealed under the Dolomitic Con-

glomerate everywhere along this line as limestone with abundant *Orthotetes crenistria* mut. K1, and other characteristic K fossils was thrown out in 1919 in digging an allotment just N.E. of Cote Grange. From this point as far as near Combe Dingle I have seen no exposure of K-beds, and at the latter place they are small and poor. The Bryozoa-bed is seen at two points, one by the path leading from Combe Mill to the Blaize Castle entrance and just west of the point of junction of the two branches of the Trym, and a second in the bed of the stream just west of the sluice gate a short distance along the path to Westbury. At both these spots the rocks are vertical or have a very high northerly dip. The path leading down to Combe Dingle from the western end of Combe Hill affords a poor section of the Z and K-beds, and in the little wood at its southern end there are some exposures of K1, consisting of grey and mottled limestone and shale. The rocks are apparently sharply folded, as in the northern part of the wood, the dip is north-north-westerly and in its southern part south-south-easterly, the dip being in each case at about 70°.

A third area where K-beds occur is in the Penpole Point neighbourhood. The only exposure I have seen there is one of reddish mottled limestone with *Productus* cf. *martini* thrown up in digging at a point about 200 yards west of Wood Lodge. In Shirehampton Park the K-beds occupy a depression between the high ground formed by the Z-beds and that formed by the Old Red Sandstone.

2. *The Zaphrentis* (Z) *Beds.*

Small exposures of the base of Z are seen by the path leading from the grounds of Avon Wood towards Press' Quarry.

Passing northwards from the Avon Section the first exposure of the Z-beds is in allotments in the fields north of Stoke Park road. In 1918 highly fossiliferous Z1-beds were exposed close by in the main road. A small exposure of crinoidal limestone occurs at the top of Parry's Lane and another containing *Orthotetes crenistria* and *Spirifer clathratus* at the corner of the road north of Eastfield House, Westbury.

In the grounds of Holmwood, Westbury-on-Trym, there are many highly fossiliferous exposures of the Z-beds dipping S.E. A little quarry at the western end of the wood, just beyond the garden wall forms an excellent collecting ground for Z1 fossils, while higher beds are seen along the path leading to the Southmead quarries.

In the large field between Elmfield and Greenway Farm much Carboniferous limestone débris has been thrown up by the plough. The material is to a large extent unfossiliferous dolomite and pro-

1. Q. J. G. S. vol. LXI. (1905) pp. 181-307.

bably comes from the base of Z. No fragments indicating the top of the K-beds were met with.

As one passes up the Brentry road dolomitized crinoidal limestone with *Spirifer clathratus* and other Z-bed fossils is exposed by the roadside. The dip is difficult to ascertain, but the rocks appear to dip at 45° N.N.W. Z-beds are poorly exposed in the old quarry to the west of the road on Henbury Hill, the dip here being probably about 80° N.N.W. From this point westwards as far as near Combe Dingle there are several small quarries with Z-beds and many exposures of fossiliferous limestone in the woods. All along here the beds have a very high dip or are actually inverted as in the little quarry to the north of Combe Farm. The strata near Combe Farm have not a uniform dip as in the lane by the farm a north-north-westerly dip is seen. A south-south-easterly dip implying inversion or sharp folding is also to be seen at Bowden's field near Combe Dingle. Z-beds are poorly exposed in the lane to the north-west of Hillside. No other exposure of the Z-beds is seen for about a mile, the next exposure being a small one in Shirehampton Park, a quarter-of-a-mile west of the Iron Bridge ; here highly fossiliferous crinoidal limestone (top of Z2) is seen with the normal northerly dip.

Penpole Point is formed of Z-beds, the lower (Z 1) beds being exposed almost continuously along the southern scarp while the upper (Z2) beds are seen in the big quarries along the northern face.

(3) *The Syringothyris* (C) *Beds.*

There are very few exposures of this horizon in the south-western part of the area, except in the neighbourhood of the Gully where the *Caninia*-oolite crops out at many points, and near the old track leading from the northern end of the Rifle Range quarry to the Downs where there are exposures of the *Caninia*-dolomite. No other exposure of the C-beds occurs for a distance of two miles, *i.e.*, till the Southmead quarries are reached. These quarries which are opened along the strike of the rocks, provide a magnificent section of the *Syringothyris*-beds nearly half-a-mile long. They were opened for the sake of the *Caninia*-oolite, which with the base of the overlying *Caninia*-dolomite forms a scarp on the eastern side of the quarry, while the *Laminosa*-dolomite forms the dip slope on the west. Good exposures are seen of the Suboolite-bed in the Bathing Pool quarry. Vaughan (p. 234) describes the section somewhat fully. A short distance north of the point where the quarries end is an exposure of the top of the *Caninia*-oolite and of the base of the *Caninia*-dolomite with algal layers. This exposure is out of the line of strike of the main exposure and the outcrop has probably been shifted westward by a fault.

In the northern limb of the anticline, the strip of country occupied by the C-beds which extends across Henbury Hill and

the golf course on Combe Hill is almost devoid of exposures, but the different levels can be recognised along the path leading through the Blaize Castle grounds to the Pennywell entrance. The rocks along this path are practically vertical. A fault occurring near the western boundary of Blaize Castle grounds shifts the outcrop of the C-beds about ¼ mile to the north, and then they extend westwards forming the main part of King's Weston Hill. Exposures are not numerous, but the *Caninia*-oolite is seen in the path leading down from the Roman camp to Echo gate, and there are several exposures of the same horizon in the woods along the northern slope of the hill. There is a small exposure of the *Laminosa*-dolomite at the northern end of the path leading from Echo gate to Combe Dingle. The considerable quarry near the western end of the hill is in the main in *Caninia*-oolite, but in the northern part *Caninia*-dolomite is seen dipping at about 45° below the oolite, the rocks being inverted. The quarry still in work (1919) in the wood at the south-western end of King's Weston Down is in *laminosa*-dolomite with a south-south-easterly (*i.e.*, reversed) dip of 60°. In the road cutting below the Iron Bridge, *laminosa*-dolomite is seen south of the Bridge, *Canina*-oolite north of it. It is very difficult to be certain about the dip, but I think the rocks are vertical. Small exposures of *laminosa*-dolomite are seen by the path west of the Iron Bridge.

(4) *The Seminula* (S) *Beds.*

The S-beds are more fully exposed than any other horizon. Their outcrop is seen along the edge of the Downs as far as a point West of the end of Northcote Road. The lowest beds exposed in the road-cutting leading up to the Downs from Proctor's Fountain are the top of the "Concretionary" beds, and the same beds, including coarse white oolite are seen at the edge of the Downs overlooking the big bare rock-face South of the Rifle Range Quarry. The quarry (now filled up) near the top of Pembroke Road was in the upper S_2-beds. Just to the north of it near the air shaft the base of the "Concretionary Beds" is fairly well shown. The shallow workings to the south of the Reservoir are partly in S_1 beds which include white china-stones, but those nearer the edge of the Downs are in *Seminula*-oolite (S_2) ; Vaughan (p. 233) gives a list of fossils from the S_1 beds here. The district known as "the Quarry" to the west of Black Boy Hill is now built over, but at least one exposure of limestone is still to be seen. The rocks here are upper S_2, and many finely weathered specimens of the "Concretionary Beds" may be seen built into the walls to the north of Worrall road. In the quarry to the north of Worrall road there is a big exposure of S-beds dipping S.E. at 35°, but they are in poor condition for examination. There is an exposure of S-beds

on Black Boy Hill and at the present time (1919) limestone with *Seminula* bands is seen in a bit of waste ground to the north of the Tramway company's establishment on Black Boy Hill.

In the big quarry now used as a garden lying between Durdham Park and the Westbury road there is a fine section of the greater part of the S-beds and a bedding plane with *Lithostrotion basaltiforme* and *L. martini* finely weathered out is conspicuous. This band is probably on the horizon of the *Lithostrotion basaltiforme* band in the Rifle Range quarry of the Avon Section. Higher up in the series are massive limestones with four bands of chert and much *Lithostrotion martini*, and overlying them is a good section of *Seminula*-oolite. Above this are more massive limestones with *Lithostrotion martini* and bands full of *Chonetes papilionacea*, while the highest beds seen at the southern end of the quarry are the lowest "Concretionary Beds." The "Concretionary Beds" dipping east at 35° are finely exposed at a point 150 yards south of St. Alban's Church, Coldharbour Road. Between Halsbury Road and Upper Cranbrook Road, New Clifton, there was formerly a small exposure of the *Seminula*-beds. Vaughan (p. 234) refers to this exposure as in Westbury Park, near Coldharbour Farm. In this neighbourhood much *Seminula*-bed material with *Chonetes papilionacea* and *Lithostrotion martini* has been thrown out during the last few years in digging allotments. From the neighbourhood of Henley Grove to near Southmead no exposures of S-beds are seen, in part owing to the westward extension of the Lias. The last exposure of the S-beds before the limestone finally disappears under the Lias is in a quarry about 300 yards N.N.W. of the Barton Regis Union; here *Lithostrotion martini* is abundant.

In the northern limb of the anticline exposures of the S-beds are frequent from Upper Knole on the east to Lawrence Weston on the west. It will be convenient in describing them to begin at the eastern end and work westwards. The big quarry south of the road at Upper Knole shows a fine section. The main part of the quarry is in fossiliferous *Seminula*-oolite, the beds lying vertically. The southern part of the quarry provides one of the finest sections of the "Concretionary Beds" in the district. Bedding planes show the algal nodules finely weathered out, while when the rocks are broken across the bedding the "Cotham Marble" structure is remarkably well seen. The "Concretionary Beds" are slightly overfolded, dipping at 75° or 80° under the oolite.

Passing westwards the S1-beds are seen in a small overgrown quarry east of Brentry Farm, and here the rocks are vertical. In the long quarry at the side of the road at Brentry Hill there is a splendid section from D1 to the bottom of S2, the "Concretionary Beds," which are about 100 feet thick, being very well seen, and including about eight well-marked concretionary bands. The

shaly partings are sometimes crowded with *Seminulas*. While part of the limestone between the concretionary bands is oolitic much is of calcite-mudstone type. The main part of the quarry is in massive grey limestone representing the *Seminula*-oolite. The old overgrown quarry opposite to the turning to Upper Knole is in S1 — in the main very compact dark china-stone, weathering white and with *Seminula*-bands. Exposures of the S-beds occur in the grounds of Henbury Hill House, but the next exposure of importance as one passes westward is in the big quarry on Henbury Hill at the eastern end of the golf course. Here the rocks (*Seminula*-oolite) dip at 80° to 85° N.N.W., *i.e.*, they are nearly vertical. Several small exposures of S-beds occur in the golf course, and in Blaize Castle grounds the same rocks are seen in the neighbourhood of Goram's chair.

A fault passing from Bowden's fields to Echo Gate shifts the outcrop northwards, and the only remaining exposures of undoubted S-beds are near Lawrence Weston. One of these is in the old quarry at the north-eastern corner of Greenhill Plantation, where disturbed reddish limestone with shaly partings and grit bands dips N.W. at 70°. The presence here of *Caninia cylindrica* mut.S 1 with *Lithostrotion martini* shows the horizon to be upper S 1. The other is in the field west of Fernhill, where small exposures of algal limestone from lower S1 occur.

In the neighbourhood of King's Weston House the Survey Map shows a patch of Old Red Sandstone. The rocks are a good deal disturbed and practically vertical. Lithologically the sandstone does not resemble the local Old Red Sandstone, being very uniform in character, and free from pebbles. I am inclined to think it is a local sandy development of S1, comparable to those occurring at this level to the west of Wraxall, at Sodbury, and at Olveston.

Observatory Hill consists of the S 2 beds repeated by the Clifton fault, and an interesting section occurs on the right of the road leading to the Bridge. The higher beds seen are the base of the "Concretionary Beds" and several well-marked concretionary bands are exposed. Below come white partly oolitic limestones crowded with *Seminula*, *Carcinophyllum mendipense* and *Syringopora*. The *Seminulae*, which sometimes show the spiral arms, often have the carbonate of lime deposited concentrically round them forming the *Seminula*-pisolite structure of Vaughan. An equally fossiliferous exposure of this bed is seen by the winding path leading up to the Observatory. Below come white limestones, largely oolitic, seen in the old quarry near the Observatory where they dip at 25° S.S.E. Along the northern margin of the Camp on Observatory Hill are many exposures of the S-beds, including two bedding planes which show the concretionary structure remarkably well. These beds which dip nearly due east while the normal dip is S.S.E., have probably been carried northward by one of the

minor thrust planes which traverse the limestone of Observatory Hill. Their discordant dip is probably due to the close proximity of the Clifton fault.

(5) *The Dibunophyllum* (D) *Beds.*

This horizon is comparatively little exposed. The upper D1-beds, chiefly consisting of massive red grits and coarse oolites, are well seen by the side of Bridge Valley Road, while the lower D1-beds, consisting sometimes of white oolitic limestone, sometimes of pseudobreccia, are seen by the side of the road leading from Proctor's Fountain up on to the Downs. Pseudobreccias are also well exposed by the railings at the northern corner of "Fairyland" and along the edge of the Downs as far eastward as opposite the entrance to the Zoological Gardens. Grits and less often limestones of D1 and D2 age are exposed at various points between the Promenade and Bridge Valley Road. Vaughan (p. 234) gives a list of fossils found in the exposures at the edge of the Downs.

Nothing more is seen of the D-beds till the northern limb of the uplift is reached. In the old quarry to the north of the road at Upper Knole, D1-beds consisting of limestone with *Cyathophyllum murchisoni* and red shaly bands containing giganteid Producti are inverted dipping at 65° below the S2 beds of the big quarry to the South. There are many exposures of white limestone containing D1 fossils in the wood which bounds the grounds of the Royal Victoria Home, Brentry, on the north, and the base of D1 is seen at the northern end of the long roadside quarry at Brentry.

Castle Hill, Blaize Castle, and a large part of the grounds to the south of the Trym also consist of D-beds. Along the path leading from the Henbury Hill Lodge, coarse oolites and red grits are seen dipping S.S.E. at 80°. An east-north-easterly strike, the normal one for this part of the area, is not everywhere maintained for many exposures have an easterly dip; others a westerly. It is clear that the rocks are a good deal disturbed, and this explains the fact that they have a wide outcrop, in spite of the dip being very high. It is necessary, however, to be on one's guard against mistaking masses which have slipped down into the ravine for rocks in situ. Vaughan (p. 235) gives a list of D2 fossils found at Blaize Castle.

D-beds repeated by the Clifton fault form a band with a maximum width of nearly 300 yards, which extending on the west from the Old Zigzag path to near Windsor Terrace, stretches eastwards with a gradually decreasing width as far as the Victoria Rooms. The tract being completely built over, there are few exposures. Several are, however, seen in the western part of

Victoria Street, and in some of them the coarse oolite so characteristic of the D-beds is well seen. Pseudobreccias are well exposed near the top of the Old Zigzag path. Some years ago, when King Edward's statue was being erected in front of the Victoria Rooms, the excavations for the purpose showed that the rock there was the extreme top of the D-beds. The characteristic fossil *Productus scabriculus* occurred abundantly. Many exposures of red grit occur in Clifton Wood and to the north of the Hotwells. Thus there is a big exposure under the western end of the Paragon, another one opposite the end of Cornwallis Crescent, and another at the eastern end of Clifton Wood Terrace. Probably some of these are bands in the D-beds, but it is impossible here to accurately map the boundary between D^2 and the Millstone Grit.

4. Conclusion.

The only point of general interest to which allusion might be made is the existence of a line of disturbance extending along the northern limb of the uplift from Kingsweston to Upper Knole. Along this line the rocks are often vertical or overfolded.

My thanks are due to the many people who have kindly allowed me to explore their grounds, and in particular to the late Mrs. Harford, of Blaize Castle, and Mr. S. H. Badock, J.P., of Holmwood, Westbury-on-Trym.

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REPORT OF COUNCIL.

To December 31st, 1919.

THE year has been a success both on account of the improved attendance at the meetings, and the number of new members elected ; also because the papers read proved to be of special interest, and were all given by members or local scientists.

The membership has received an addition of 23, of which 19 were ordinary and 4 associates under the age of 21 ; and what is equally gratifying, there were only 3 resignations. Thus in the last 2 years the Society has added 40 new members and lost only 5 by withdrawals, and the total membership now stands at 144.

Another point to be noted is that three Associates have become Ordinary members, an example which is hoped will be followed by others.

The "Proceedings" for 1917 were published early this year and distributed to members and Corresponding Societies. This formed Part I. of Vol. V. 4th S., and the contents for Part II. have been prepared and are in the Press.

Council has thought it adviseable to alter some of the Laws, and the opportunity was taken to revise them throughout. This was done by a Committee at a series of meetings, and its work has received the approval of Council, and it is proposed to submit them for members' acceptance at an early date.

In December a Special Meeting was held, convened by 7 members, about holding, during the session, additional but informal Exhibition Meetings, in order to offer opportunities for present and new members to show an increased interest in Natural History on different lines. After full discussion it was decided by vote that the experiment should be tried, and the holding of them should not be added to the work of Council, but left entirely in the hands of the Sections to arrange.

A Summer Excursion took place in June to the Clifton Zoological Gardens, and was very well supported. The Society was received by the President of the Gardens, and the celebrated collection of Ferns was explained.

On January 9th members were invited by the Committee and Director of the Bristol Museum to a reception held to pay honour and thanks to the retiring President, Mr. G. C. Griffiths, for the great help he had long given to the arrangement for their Entomological collections.

There were eight General Meetings, including an Exhibition night, which as stated before were very successful in interest and in attendance of members.

IDA M. ROPER,

Hon. Secretary.

The HON. TREASURER in Account with the BRISTOL NATURALISTS' SOCIETY.

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,, Donations		12	6	,, Postages, &c.	4	13	3
,, Sale of "Proceedings"	6	5	9	,, Gratuities	2	0	0
,, Balance forward	49	5	3	,, Balance due to Hon. Treasurer ..	1	1	7
,, Balance due to Hon. Treasurer ..	1	5	5	,, Cash in hand and Bank	67	1	10
	£110	3	11		£110	3	11

Audited and found correct,

ERNEST H. COOK
CHARLES BARTLETT, A.C.A. } *Auditors*

December, 1919.

LIBRARIANS' REPORT.

For the Year 1919.

WITH the increased membership of the Society there are distinct signs that the Library is valued both for reference in the room, and for fuller study at home.

It is felt, however, that many members do not make full use of the good collection of books placed at their disposal. There were less than 20 books not returned at the end of the year, and 13 of these were of recent issue.

Current publications of Corresponding Societies have been received up to their latest issues, and if it appeared any previous numbers had been missed enquiries were made with satisfactory results. It is a matter of much regret that no binding has been carried out to keep in order these series of publications, which contain the latest researches of the leading scientific bodies, but there are no funds available for this pressing need.

The Ray Society, to which we subscribe, has sent its annual volume, the latest being *British Freshwater Rhizopoda and Heliozoa*, by Wailes, Vol. 4.

Thanks are given to the following donors of books :—

"Royal Society Philosophical Transactions," 1918, from Dr. Sydney Young.

"Observations on Ecology of *Epilobium hirsutum*," from Miss Lily Batten.

"Linnean Society's 'Proceedings'" to date, from Mr. J. W. White.

"Geological Magazine" to date, from the Geological Section.

Two Economic Guides on "Mosquitoes" and "Rats in England," from the Trustees of the British Museum.

The general demand for our "Proceedings" has been well maintained, and the usefulness and importance of papers issued in them of various years were clearly brought out on the visit to Bristol of the Geologists' Association, when many spare copies and reprints were gladly obtained by the visitors.

The American Universities also show by the applications received their wish to make sure they obtain all our publications.

ARTHUR B. PROWSE, Lieut.-Col., R.A.M.C.,
Hon. Librarian.

IDA M. ROPER, F.L.S.,
Hon. Sub-Librarian.

Exchange List.

Ashmolean Natural History Society of Oxfordshire
Barrow Naturalists' Field Club
Belfast Naturalists' Field Club
Birmingham Natural History and Philosophical Society
Bristol Museum and Art Gallery
——— University of, Speleological Society
British Association
——— Museum (Natural History), S.W.
Cardiff Naturalists' Society
Chester Natural Science Society
Cornwall, Royal Geological Society of
———, Royal Institution of
———, Royal Polytechnic Society
Cotteswold Naturalists' Field Club
Croydon Natural History and Scientific Society
Ealing Scientific and Microscopical Society
Edinburgh Geological Society
——— Royal Botanic Society
Essex Field Club
Geological Society of London
——— Survey and Museum, London
Geologists' Association
Glasgow, Geological Society of
——— Natural History Society of
——— Philosophical Society
Hertfordshire Natural History Society and Field Club
Liverpool Geological Society
——— Literary and Philosophical Society
——— Science Students' Association
Manchester Literary and Philosophical Society
——— Microscopical Society
——— Museum Library
Marlborough College Natural History Society
Norfolk and Norwich Naturalists' Society
North Staffordshire Field Club
Nottingham Naturalists' Society
Plymouth, Marine Biological Association of the United Kingdom
——— Institution, and Devon and Cornwall Natural History Society
Quekett Microscopical Club
Royal Irish Academy
Royal Microscopical Society
Rugby School Natural History Society
Torquay Natural History Society
Woolhope Natural History Field Club
Yorkshire Geological and Polytechnic Society
——— Naturalists' Union
——— Philosophical Society

OUR "PROCEEDINGS" ARE SENT AS A FREE GIFT TO :—

British Museum Library
Cambridge University Library
Dublin, Trinity College Library
Edinburgh, Advocates' Library
Oxford, Bodleian Library
Patent Office Library, London

AUSTRALIA.

Australasian Association for the Advancement of Science
New South Wales, Geological Survey
———, Royal Society of
Queensland Museum, Brisbane
Victoria, Royal Society of

CANADA.

Canadian Institute, Toronto
Hamilton Scientific Association
Nova Scotian Institute of Natural Science (Halifax)

INDIA.

Agricultural Journal of India
Agriculture, Imperial Department of
Geological Survey of India, Calcutta

FRANCE.

Lyon, Société Linnéenne de
Rennes, University of

NORWAY.

Det Kongelige Norsk Universitet Christiania

SWITZERLAND.

Lausanne, Société Vaudois des Sciences Naturelles
Zurich, Naturforschende Gesellschaft

UNITED STATES.

American Museum of Natural History, New York
Augustana College, Rock Island, Illinois
Boston, Mass., Natural History Society
Brooklyn Institute of Arts and Sciences, Coldspring Harbour
California, University of, Berkeley
Californian Academy of Sciences, San Francisco
Cincinnati Natural History Society
———, Lloyd Library
Colorado College, Colorado Springs
———, University of, Boulder
Denison Scientific Association, Ohio
Elisha Mitchell Scientific Society, Chapel Hill, N.C.
Essex Institute, Salem, Mass.
Illinois, University of, Urbana
Indiana Academy of Science
Michigan Academy of Science
Missouri Botanical Gardens
——— Academy of Science, St. Louis
New Mexico, University of, Albuquerque
Ohio State University, Columbus
Oklahoma State University
Philadelphia Academy of Natural Sciences
———, Wagner Free Institute of Science
Smithsonian Institution, Washington
Tufts' College, Mass.
United States Geological Survey, Washington
——— National Museum, Washington
Yale University, Connecticut

ARGENTINE REPUBLIC.

Buenos Aires, Muses National de Historia Natural

URUGUAY.

Montevideo, Museo Nacional de

MEXICO.

Mexico, Sociedad Cientifica

GEOLOGICAL SECTION.

1919.

THERE are 39 members on the Register, but as some of these have not paid their subscriptions for some years and have left Bristol, their names should be taken off.

There were seven meetings during the year, with an average attendance of 28 members and friends.

The following papers and exhibits were given :—

January 23.—"Coastal features of South Wales."*
Dr. A. H. Cox, *Prof. of Geology, University of Cardiff.*

February 27.—"Landscape in History." Miss F. A. Clare.

March 20.—Geological Photographs.* Prof. S. H. Reynolds, Sc.D.

May 15.—"Coral Reefs." Miss E. E. Holt.

October 16.—Lantern Slides of the British Association Geological Photograph Committee. Prof. S. H. Reynolds, Sc.D.

November 20.—"The Balkans." * D. E. I. Innes, M.A.

December 11.—"Age of the Earth." * V. A. Eyles.

* *Illustrated by lantern slides.*

At the Annual Meeting on January 23, Prof. S. H. Reynolds, Sc.D., F.G.S., was re-elected President, and B. A. Baker, F.G.S., Hon. Secretary and Treasurer for the year.

According to the financial statement, the Section started the year with an adverse balance of £1 9s. 3d. The total receipts amount to £4 2s. 6d., with an expenditure of £3 4s. 3d., showing a balance of 11s. due to the Hon. Treasurer.

B. A. BAKER,

Hon. Secretary and Treasurer.

ENTOMOLOGICAL SECTION.
1919.

SIX Meetings have been held during the year, and the continued increase in the number of Members of the Section has resulted in some interesting discussions and exhibits.

January 19. — Mr. G. C. Griffiths, F.E.S., was re-elected President, and Mr. C. Bartlett, Hon. Secretary. Miss Roper exhibited *Peizodorus lituratus*, found on wild celery. Mr. G. L. Dear, *Plusia moneta*, Redland, 1918. Mr. G. C. Griffiths, *Sesüdae* and *Anthroceridae* of the Vaughan collection, Bristol Museum.

February 28.—Mr. G. C. Griffiths introduced the subject of Mimicry, tracing its origin and producing the original paper of Bates, with plates of *Heliconidae* and *Pieridae.* Many species illustrating the theory were exhibited by members. Miss Roper communicated notes from Fabre's article on Mason Bees.

March 28.—Mr. H. A. Francis made some interesting observations upon the legs of bees, principally the honey bee, and comparisons with other species and their parasitic enemies. Miss Roper exhibited buds of sallow attacked by the fly *Rhabdophaga rosaria.* Mr. C. T. Gimingham, *Oxipterum pallidum,* parasitic on the swift.

April 25.—Mr. A. E. Hudd read a paper on Mosquitos, and noted the importance of the study of their life histories, and referred to the ravages of diseases transmitted by these pests and the steps taken to combat them. Many exhibits were produced by members.

November 14. — Mrs. Sandwith, Diptera and *Sesia ichneumoniformis,* Clifton Down. Col. T. Jermyn, *Mutilla europaea,* male, Shapwick, and female, Dorset, *Eristalis aeneus* and *Psithyrus quadricola,* Weston-super-Mare. Mr. C. Bartlett, Lepidoptera, captured in the New Forest, June, 1919, and *Trogus exaltatorius,* bred from a pupa of *Sphinx ligustri.* Mr. T. F. Hewer, *Depressa quadrimaculata* and *Æscna grandis,* Cadbury Camp. Mr. H. Womersley, Diptera. Mr. G. C. Griffiths, genera of *Colias, Papilio,* etc.

December 19.—Exhibits: Miss Roper, figwort with pupae of *Cionus scrophulariae.* Mr. C. T. Gimingham, *Pteromatus endomychi,* bred from the pupae of the beetle *Endomychus cocinneus,* and *Platyrrhinus latirostris,* Long Ashton. Mr. C. Bartlett, Coleoptera, taken in the New Forest, June, 1919, including *Callidium violaceum, Leptura scutellatum, Asemium striatum* and *Anoplodera sexguttata,* also Neuroptera, *Anax imperator* and *Cordulea œnea.* Mr. G. L. Dear, *Polygonia c-album,* var. *hutchinsonii.* Mr. J. W. Norgrove, *Heliothis armigera,* Frenchay. Mr. G. C. Griffiths, species of *Noctuae,* including *Pachnobia hyperborea, Hadena pisi,* and others showing variation, also genus *Pseudacraea* from Africa. Mr. James, fine variety of *Argynnis adippe,* New Forest, 1919. Dr. B. N. Blood, excellent photographic slides of the minute hymenopterous parasites, *Mymaridae,* including new and unnamed species.

CHARLES BARTLETT, *Hon. Secretary.*

Account of the Annual and General Meetings.

January 9th, 1919.

A Special Meeting was held at the Bristol Museum, by invitation of the Committee and the Director, in order to show their appreciation of the assistance given for the past 16 years by Mr. G. C. Griffiths, F.E.S., the retiring President, and by other members in supplying information and in arranging the Entomological specimens in cabinets.

About 100 members were present, and an inspection was made of the Barton and Vaughan collections of Insects, and the model of the Bristol Coalfield, the points of which were explained by members.

After light refreshments, the Chairman, Mr. J. Fuller Eberle, and the Director, Mr. H. Bolton, welcomed the Society to the Museum, as doing kindred work, and thanked the members for the willing help given. They looked forward within a few years to add to the size of the Museum, and to make it possible to provide a room in the new buildings for meetings of the Society and others with like objects.

THE 56TH ANNUAL MEETING.

January 16th, 1919.

Dr. E. H. Cook was elected President, and Dr. W. H. Hoyle and Dr. W. A. Smith Vice-Presidents, with minor alterations in Council. The retiring President, Mr. G. C. Griffiths, F.E.S., delivered an address entitled "Camouflage in the Insect World" (printed in abstract on page 121).

THE 473RD GENERAL MEETING.

February 6th, 1919.

"Aims of Economic Entomology," by Mr. A. H. Lees, M.A.

In ancient times the Kings and Priests made it part of the National Religion to control insect pests and murrains, whilst modern science has found it better to study the life history of such insects, and by vigorous interference at some stage to stop their ravages.

As affecting man himself examples of this treatment are to be found in destroying, chiefly by paraffin sprays on the breeding pools, the larvae of certain species of gnats and mosquitos, whose bite transfers yellow fever and other tropical diseases.

Animals in England are not free from attack by certain flies but of more importance and within some control, is the destruction

wrought to fruit trees and food crops by minute insects or fungoid growths. Nature helps by providing birds, or insects such as Ichneumon flies, to get rid of some, but the results are small, and man must use all his ingenuity to save his crops from serious injury.

In orchards and gardens some success is achieved by spraying the eggs, or by banding with grease-cloths the tracks from the breeding places in the ground to the young fruit buds. Another method is the saturation of the air around the plants by strong gases to upset the instincts of the insects, or the growth of the fungoid parasites.

With lantern slides to illustrate the habits of many insects, the details of the struggle carried on were described.

Exhibit by Miss Ida M. Roper, F.L.S., of catkins of the diœcious shrub, *Garryea elliptica,* the pistillate form being rare.

THE 474TH GENERAL MEETING.

March 6th, 1919.

"Dust and Dirt," by Dr. O. V. Darbishire.

When starting on a new branch of Natural History patience is needed, together with a knowledge of methods and available appliances, to secure success. With dust and dirt so freely surrounding us examples are readily obtained to learn much about bacteria and vegetable moulds, but from their very number care is needed to separate the species, and this can be done by the use of a trap to catch dust in Petri dishes on a mucilage of Agar (a gelatinous seaweed). After cultivation for 3 or 4 days in an incubator at a fixed temperature of 21 ° C. it is possible to pick out a few specimens for the microscope, and grow them separately. From ordinary dust the organisms found will fortunately not number above a dozen kinds, but from such material as wet horse droppings, liquid sewage, or a decoction of hay, large quantities of moulds may be secured. These will usually range themselves under three genera, such as *Mucor, Penicillium* and *Eurotium,* and their examination as pure cultures affords much information. These flourish in damp and darkness, whereas fresh air, sunlight and dryness quickly destroy them. In their place, however, their activities are of value as scavengers, and to act as ferments and turn dead material to water and gases.

Exhibits by Mr. H. J. Gibbons of the eggs of *Orgyia antiqua,* and a twig of black currant infected by *Eriophyes ribis,*

THE 475TH GENERAL MEETING.

April 3rd, 1919.

I. "How Fossils are preserved," by Miss Edith Bolton, B.Sc.

Fossils are the remains of animals or plants, or moulds of them, changed by chemical or mechanical processes into mineral substances and preserved in rocks. The various kinds of fossils are produced by the tissues being replaced by minerals, atom by atom, or by a mould of the interior or exterior, by the slow deposit of sediment, as carbonic acid in the water dissolved away the original matter. Apart from these special forms, there are those consisting of the shell only, or a solid fossil deposited within a previously made mould. The Coal beds are the largest of all fossil matter, and are plants turned into carbonized material retaining within the shapes and minute markings of plants that were not decomposed before the coverings were made solid by pressure. Another variety of these is the collection of seeds and small parts of vegetation rolled together in a ball and thus preserved, so as to be slowly turned to coal without breakage.

II. "Notes on Medical Entomology," by Mr. E. S. Baynes.

Insect horrors are found in the fly and Anopheles, or British gnat, with the flea and bug, which exist amongst dirty surroundings, as carriers of disease, and their forms and habits prove their adaptability. The louse, however, as a clean wingless human parasite is equally a carrier. The giving of Army rank to expert entomologists, for them to study obscure problems in the field and remit their observations to be elucidated by research workers at home, has led to numerous improvements in preventive medicine. One result has been the definite knowledge that trench fever is caused by a microbe existing sometimes within lice. A description of the life history and habits of the louse showed its suitability for distributing the microbes, or in producing the high percentage of head disease amongst school children.

Exhibit by Miss Ida M. Roper, F.L.S., of examples of wrapping paper manufactured from stems of *Spartina Townsendi.*

THE 476TH GENERAL MEETING.

May 1st, 1919.

"Oxygen in Mine Rescue Work," by Dr. E. H. Cook.

Rescue work in mines following explosions needs for success a special set of appliances with a proper method of working them. The general conditions to be fought in the absence of ordinary atmosphere are the presence of nitrogen, carbon dioxide, and carbon monoxide, the latter being the worst, because it destroys the functions of the blood. Rescuers, therefore, carry with them a supply of oxygen, made very pure under tests, stored in reservoirs

under pressure; and a rubber bag to receive their expired breath, which becomes again purified for use by caustic soda.

Apparatus of this kind works successfully in trained hands, with calm movements, and suffices for 2 hours with a supply of about 1½ litres of oxygen per minute. Details of the appliances in use vary, including liquid air (60 % oxygen) instead of oxygen gas, but the Proto apparatus is the most extensively used. Every colliery has its own set, and men are regularly trained in its proper working.

To illustrate the subject Mr. Moore, the head of the Mines Rescue Station at Bristol, put on before the members one of the complete suits provided for the staff.

ANNUAL EXCURSION.

June 18th, 1919.

The Summer Excursion was made to the Zoological Gardens, Clifton, where much interesting information was obtained and discussed. Dr. Harrison received the members on behalf of the Gardens Committee and pointed out special attributes of animals and shrubs, whilst Mr. Harris, the head gardener, explained the many choice varieties of the Ferns. Votes of thanks were passed, including one to the Hon. Secretary for the admirable arrangements for tea.

THE 477TH GENERAL MEETING.

October 2ND, 1919.

Exhibits of Natural History by the Members.

A varied and suggestive series of exhibits were shown, and the President, Dr. E. H. Cook, revived by his experiments a portion of the Society's work that had been passed over for some years. He demonstrated chemical and physical laws in the simple methods of detecting minute percentages of substances when mixed with large quantities of other matter. These were chemicals in water (colour, taste, smell), sodium in flames, and radium near the electroscope.

Mr. G. C. Griffiths, F.E.S., the moth, *Ennomos autumnaria*, bred by himself; and *Euschemon rafflesiae*, a butterfly from Australia, which alone has the wing fremulum of the moth. Miss Bryant, fossil shells from red crag of Suffolk. Mr. C. Alden, polished stones containing fossil *Lonsdalia floriformis*; and other specimens from the Avon Gorge.

Dr. A. B. Prowse, seedlings of *Mimosa pudica*, from seeds from India, of which 50 % germinated after being dormant for 37 years. Miss I. M. Roper, F.L.S., leaves of *Platanus acerifolia*, and four other varieties of Plane trees planted in the streets of Bristol.

Mrs. Sandwith, *Tipula gigantea*, from Leigh Woods; and a species of the Borage family found locally and unknown in Europe.

Other members exhibited birds, coloured photographs of fungi, Coleoptera, etc.

THE 478TH GENERAL MEETING.

November 6th, 1919.

"The Isle of Purbeck: Its Geology and Scenery," by Prof. S. H. Reynolds, Sc.D., F.G.S.

The land called by this title is one of the most interesting areas in the British Isles to the geologist. It shows so clearly the relations between surface form and geological structure. Away from the coast the most important feature in determining surface form is hardness, the relatively hard Chalk and Purbeck-Portland beds forming uplands, while the softer Tertiary and Wealden beds form lowlands. The character of the coast depends in part on the hardness and on the porosity of the strata, in part on their inclination. Where the coast is formed of Portland and Purbeck beds lying horizontally vertical cliffs occur. If in addition to the Portland the Kimeridge Clay rises above sea level, the Portland beds slip over its surface and a tumbled undercliff results. If the beds, as to the west of Gad Cliff, are highly inclined, as long as the hard Portland beds form a resistent barrier to the waves the coast is regular, but at a number of points the barrier or screen has been broken through, and then the remarkable coves, of which Lulworth is the most noted, have been worn in the soft beds behind. The famous Lulworth "Fossil Forest" is described, and the remarkable "burrs" of carbonate of lime formed round the stumps of the trees (cycads).

THE 479TH GENERAL MEETING.

December 4th, 1919.

"Sexual Selection in Birds," by Prof, C. Lloyd Morgan, F.R.S.

The study of sexual selection affords reasons for inherited instincts and intelligence, where, for example, they cause the robin, plover, and reed-warbler to hold a limited territory against all comers, because it has a prospective value for the maintenance of the family. Sexual preference must not have too high a value put upon it, but rather be regarded as co-ordinate with natural selection. The secondary sexual characters of gaudy plumage in the male, or beautiful song, seem to have developed as an expression designed to make an impression on the female, which is not led on that account to choose deliberately such males, but because inherited instincts cause her to recognise super-normal activity and vitality to be of great prospective value in reproduction and race maintenance. Mention was made of the behaviour of birds at mating time, as observed by Mr. Elliot Howard, who made it a hobby in the midst of his active life in commerce, and the intricate subject was treated with great clearness, as shown by the hearty appreciation of the audience.

PRESIDENTIAL ADDRESS.

By George C. Griffiths, F.E.S.

"Camouflage in the Insect World."

DURING the Great War of our own day we have constantly heard of batteries, observation posts, and other important points, covered with leafage or trunks of trees, whilst a staff of experts at the War Office has been constantly busy in devising new forms of concealment. At one period of the War, too, a shadowy presentment of some of our most formidable ships kept part of the North Sea, whilst the iron giants themselves were many miles away. Also in our own harbour here, we have seen merchant steamers painted in a fantastic array of curves and stripes of various colors, suggesting almost the weird nightmare of a demented ship's painter, yet being a deliberate and often successful effort to foil by dazzlement the deadly submarine.

But there is, and has been through the world's history, another warfare, pitiless and truceless, the struggle for Existence, and this has brought into being amongst the animal kingdom devices of Camouflage, even more complete and wonderful than those on which we have briefly touched. Some of these disguises I wish to mention to you to-night.

If we look at one of the great bright green caterpillars of the Privet hawk-moth, as we hold it in our hands, what can be more conspicuous? Three inches or more in length, and as thick as a finger, its apple-green body has stripes of lilac, edged with white, seven in number, on each side. Its head is probably raised, showing an emerald green face, bordered with brown, and on its tail is a formidable looking horn. But place the creature on a branch in the midst of a privet-bush, and it straightway disappears from view, though you would judge that the narrow leaves, could scarely serve for its concealment. The side-stripes cut up the bulk of the caterpillar, and thus make it resemble the privet leaves and their shadows, whilst the creature's face simulates one of the unripe berries, which at that season are precisely of the same shade of green, the brown border giving the requisite globular appearance.

If we are fortunate enough to meet with the singular caterpillar of the Lobster-moth (*Stauropus fagi*), which I have twice beaten out of lime in Leigh Woods, where it is very uncommon, we find another and very different form of disguise. The larva, when young, strongly resembles a red ant, the second and third pairs of legs being long, and very different to those of most Lepidopterous larvae. When full grown and at rest, it much resembles a curled and withered leaf of the beech, which is its usual food, as the scientific name of the moth implies. The tail

claspers of the larva are modified into two long thin appendages, which are often held together and represent the leaf-stalk. The legs are doubled up and resemble the bunches of brown scales which enclose the buds of the beech, and hang down after the latter are unfolded. But if the caterpillar be disturbed, it at once throws its fore part almost upright, and waving its elongated legs in a most threatening manner, seems like a great spider preparing to spring upon its prey. At the same time, the hinder part of the body is erected, so that the two tail appendages are protruded above the head, and the movement of these and the sides of the body help to add to its grotesque and alarming alarm-appearance. Müller has suggested that this spider-like appearance is a defence against the attacks of ichneumon flies, which, he has observed, keep out of the way of spiders and are rarely found in their webs. This is rendered still more probable by the fact referred to by Poulton, that on the fourth and fifth body-rings there is an intensely black patch sunk below the surface and covered by a flap when the creature is at rest. When irritated this flap is lowered and the patches become visible, giving, as Müller suggests, the appearance of stings of ichneumon flies, warning off the fly by an intimation that the body of the larva is already inhabited by a parasite. Poulton points out, however, that the rarity of the Lobster caterpillar is a proof that in spite of its many devices it frequently succumbs to its enemies ; two species of ichneumon flies, at least, are known to prey upon it.

There is a caterpillar of a rather rare moth, *Acronycta alni,* one of the most striking of our Noctuae, which in its younger stages of development is exceedingly sluggish in its demeanour, and when at rest nearly always turns its head round against the body, resembling with its curious white and grey colouring, a round patch of bird's dropping. I have kept some of these larvæ, and have often been struck by this peculiar rest-attitude. But when the larva is nearly full grown and has assumed the final garb of its caterpillar life, it comes out in a startling velvet black, barred by broad bands of yellow. Black and yellow, we may remark, are perhaps the most usual colours of distasteful caterpillars, namely, those that birds refuse to eat.

One of our large Bombycine moths, *Gastropacha quercifolia,* bears a most remarkable resemblance to a bunch of brown and withered leaves, and the rest-position always assumed by it is such as to bring out this likeness to the fullest effect ; the fore wings being held almost vertically over the body, whilst the hind wings are spread out horizontally. This moth, many years ago, used to occur on the gas-lamps on Ashley Down, and I have been told this attitude was nearly always assumed, though of course the disguise would not be nearly as effective on a lamp as when occurring in its natural surroundings on a tree-trunk.

The beautiful Kentish Glory moth, *Endromis versicolora,* when at rest upon a birch tree, is described by Holland as strongly resembling a bunch of dead leaves. In the very young stage of its larval existence, however, it is described by Gascoyne as resting in companies on the ends of the small twigs, when they are compared to the little black stumps so common on the birch. When they are a little larger, they are of a dull green colour, and still sit in companies on the twigs, and then resemble its catkins ; I found this most striking on breeding the larvæ some years ago. But if these larvæ are disturbed they throw back their heads and then bear a strong likeness to the larvæ of *Tenthridinidæ,* which Poulton has proved by experiment to be distasteful to birds. When still larger, the larvæ no longer appear in companies, but rest on the twigs singly, and as the colour is now green, with yellow and dark green side stripes, the resemblance is to a half-opened leaf, where the side stripes do duty for the leaf veins.

A striking and handsome moth, the Black Arches, *Psilura monacha,* is beautifully protected in its larval, pupal and imaginal stages, by its resemblance to the lichens, which so often flourish on the various forest trees on which it feeds. The larva is thickly covered with greyish hairs and often rests on a lichen-covered branch, the pupa is black, but with tufts of hair upon it, and is enclosed in a thin loose cocoon of white silk, fastened into a chink in the bark, whilst the moth itself, its wings decorated with delicate scroll-markings on a white ground, settles itself on the grey lichens of the tree-trunks. This moth occurs much more frequently in the New Forest and in Surrey than in the more western parts of England.

The caterpillar of one of our commonest moths, *Rumia crataegata,* the Brimstone Moth, is protected in a most remarkable degree by its resemblance to one of the short blackish-brown twigs of the hawthorn, on which it feeds. If we look at these twigs, we shall probably find some of them bent in the middle, and a little projection just at the bend. This is exactly reproduced in the larva. There are several variations in the colouring of this caterpillar, but all of them seem to tend towards similarity to the trees on which they are found. Some extensive and careful experiments carried out by Prof. Poulton and Miss Lilian Gould seem, says Barrett, to prove that the varying colours of the larvæ are directly affected by their environment, " the green colour being gradually assumed by almost every larva which was fed on very green and light coloured food ; whilst those fed on old dark green leaves, with dark twigs, remained in a large proportion dark brown, Whilst watching these experiments Miss Gould discovered that. when hanging by a thread from the food-plant, the larva would whirl itself round when disturbed, and spin upon the thread with such swiftness as to become quite indistinguishable from any bit of dead leaf twirling in the wind on a thread of spider's web."

On the Scotch fir, *Pinus sylvestris*, may be sometimes found the larva of the pretty moth, *Fidonia piniaria*, the two sexes of which are strikingly dissimilar ; the caterpillar has lateral stripes which when in position on the growing pine-needles render it most difficult to detect. On the same tree we may find the larva of a Noctuid moth, *Panolis piniperda*, which is also protected in an exactly similar way ; the moth itself, however, is fond of settling on the reddish trunk and branches of the pine tree, and escapes notice by its singular likeness to the bark ; we thus find that both moth and caterpillar are protected by resemblance to their environment, though in different ways.

The pretty larva of *Larentia cæsiata*, which feeds principally on heather, is beautifully protected when upon its food plant, but the moth, with its grey-banded colouration, finds its security by resting on the grey rocks or boundary walls of the northern moors and hills, which are its principal habitat. I have taken it myself on moors in the counties of York and Durham, and it seems almost restricted to these mountainous districts, the most southern recorded locality being the Black Mountain, Herefordshire, except as to one solitary specimen taken in 1870 on Durdham Down, by a former member of our Society, the late Mr. J. W. Clarke. This specimen is now in my collection, and I have the pleasure of exhibiting it here to-night.

One of our butterflies, the Comma, *Vanessa C-album*, which is sometimes abundant in Herefordshire and the Wye Valley, and is certainly far more frequently found in the West of England than elsewhere, has with its curiously indented wings, with their dark mottled undersides, a striking resemblance to dead leaves. It has also a habit, which I have noticed once or twice in Leigh Woods, of settling on tree-trunks, where, in spite of its bright fulvous ground colour, the black spotting of the upper surface renders it quite inconspicuous.

But any account of the disguises of butterflies would be incomplete without some mention of the Kallimas or Indian Leaf Butterflies, the first records of which were made by Alfred Russel Wallace in his great work on the Malay Archipelago. The description of his first acquaintance with *Kallima* has been so often quoted that I forbear to repeat it in part, preferring rather to advise you to read it in full in his book. Other strongly leaf-like disguises may be seen in the under-sides of the beautiful genus *Anaea*, a South African group, also in the pretty little *Libythea celtis*, a South European species, which has for near relatives in its genus, *L. labdaca*, from West Africa and *L. geoffroyi* from the Austro-Malayan Region, each of which is remarkable for the long snout-like form of its palpi, and the curious foliaceous appearance of its under surface.

After dealing with so many of the insects of the Order Lepidoptera, we may just touch upon the remarkably perfect disguise of some of our Dipterous flies, which masquerade in a dress which is a close copy of that of the Humble-Bees (*Bombi*). The specimens

exhibited belong to the form *plumata* of *Volucella bombylans.* This fly, though so closely resembling the bee, may be at once distinguished by its beautifully plumed antennæ. These Dipterons lay their eggs in the nests of the Humble-bees, which they so nearly imitate, and the mimicry is Aggressive rather than Protective, as it enables the fly to pass unchallenged into the nest of the bee, and there its progeny will feed on the provisions stored for the bee-larvæ, or even upon the larvæ themselves.

The insect to which I shall next draw your attention is a beetle, though one of a very remarkable shape and appearance; so much so that its proper place in the classification of the Coleoptera has been in debate amongst different authors. Its scientific name is *Mormolyce phyllodes*, and it is a native of Java and Penang. In the latter locality, Distant states that it is known as the Fiddler, on account of the queer resemblance of its outline to a fiddle. The "Autocrat of the Breakfast Table" remarks in his delightful pages, "Nature never leaves a crack or a crevice, mind you, or a joint in a tavern bedstead, but she always has one of her flat-pattern live timekeepers to slide into it." Holmes may well have thought of this insect as an example, for certainly it is difficult to conceive of any creature which is flatter in pattern. The wide-spreading elytra are so thin and transparent that it is possible to read printing through them. The insect is found under fungi growing on the bark of or beneath the trees, usually in a shallow crevice under the fungus. If disturbed it runs away with great rapidity. The elytra are soft during life, and it is only when the beetle is dead that they assume their hard and crisp texture. Of course, this pliability enables the creature to adapt itself in shape to the cranny in which it lurks. The leaf-like appearance which gives it its specific name, must be a great protection when amongst leaves on the ground.

Some of the Orthoptera are very beautifully protected by resemblance to twigs, notably the Stick-insects or *Phasmidæ*, which carry out the likeness to a most remarkable extent, and in the fullest detail. Some are green like the young growth of a bough, others dark brown as the older twigs.

Lastly I must call your attention to the very singular leaf-insect *Phyllium scythe*, a native of India, in which wing-cases, body and legs all present the very closest approach to leaves, even the veining of the leaf being accurately reproduced. This is a vegetable feeder and perfectly innocuous to other insects, and its disguise has the sole purpose of safe-guarding the creature from its foes, thus being in absolute contrast to the leaf-like pose of the *Mantis*, which is assumed in order to enable that rapacious insect to seize its prey. With these I cannot deal this evening, and must be content simply to mention them. The whole subject is so large that it is impossible to mark its limits; I can only say in the words of the Arabian Nights Entertainments, quoted by Kipling as a motto for a recent work—"Praised be Allah for the diversity of his creatures!"

The Life of a Diatom.

By Cedric Bucknall, Mus. Bac. (Oxon.)

THE *Diatomaceæ* or *Bacillarieæ*, are minute aquatic plants forming a division of the Algæ, and are characterised by their silicified cell-wall and the golden-brown or olive-brown colour of the endochrome.

Each individual diatom consists of a single cell, invisible to the naked eye except in the case of the largest forms, and therefore practically unknown as a distinct organism except to the microscopist.

Living diatoms in masses may often be seen forming a brown film on the mud and stones of wayside pools and ditches, on the mud of tidal rivers, floating in thick masses on the surface of deeper water, or on logs and the timber of piers.

Diatoms are also found in lakes, clothing aquatic plants with a gelatinous film or growing on them as parasites ; in brackish water, on moist sand on the seashore, amongst seaweeds, and floating in enormous numbers in the open sea as plankton, especially in the Arctic and Antarctic Oceans, where they are even found growing on blocks of ice. Of their occurrence as fossils mention will be made later.

Since the invention of the achrcmatic microscope their siliceous valves have been studied assiduously, and during the last 100 years about 12,000 species have been described and named.

In form, diatoms are of every conceivable symmetrical figure—linear, oblong, square, triangular, polygonal ,circular, sometimes furnished with horns or processes of various shapes. Their valves are most variously and beautifully sculptured with ribs, lines, dots and other markings, often requiring the highest powers and finest modern lenses for their resolution. In some species over 100,000 lines to the inch have been counted. The siliceous valves being indestructible by ordinary means are easily preserved and mounted for the microscope, and the majority of diatomists in the past have been content to study them in this condition, but it is only by the study of the living plant that a true knowledge of its structure can be attained. Since the discovery of diatoms as living organisms, certain problems connected with their life-history have exercised the minds of students. As yet these problems have been only partially solved, and there is still much to be learnt with regard to their mode of reproduction and their power of movement. Several distinguished investigators have studied the life-history of diatoms, and we are indebted to Lauterborn for a very complete account of the structure, cell-division and movements of certain species which are specially suitable for the purpose. A diatom-cell consists of two *Valves*, each furnished with a marginal *Girdle-*

band, one of which fits over the other like the lid of a box. The complete cell is called a *Frustule.* One of the diatoms selected by Lauterborn for study was a large species of *Pinnularia.* This is oblong in form and rectangular in section, and each valve is furnished with marginal, transverse, hollow ribs, which leave a clear median longitudinal space, and have openings communicating with the interior of the cell. In the median space there are two terminal and one central nodule connected by two longitudinal clefts which together form the *Raphe* and open to the exterior by pores at the central nodule. If we examine a living specimen of this diatom with a power of 200 or 300 diameters, we see that it is coloured greenish-brown by a layer of chlorophyll. This is sufficiently transparent to allow of a central mass or bridge of protoplasm being visible, and this contains the nucleus of the cell. Sometimes we can discern in the protoplasm short, slender rods in pairs, which generally point towards the centre, and also traces of delicate protoplasmic bands which extend to the ends of the cell.

There are, irregularly scattered, or sometimes in fixed positions, globules of different sizes, some of which consist of oil, and in some species there are vacuoles containing bodies named after their discoverer, "Buetschli's red granules," and also small bodies containing albuminous protein called *Pyrenoids.* Starch is absent. With a high power lens of wide aperture the protoplasm is seen to be reticulate or honeycombed in structure, and, treated with various stains and reagents, the nucleus, with one or more nucleoli and a small body called the *Centrosome,* becomes more visible. The nucleus also shews a reticulate structure with minute granules of chromatin at the nodes of the network.

The mode of reproduction in diatoms is only partially known, but multiplication by cell division is common to all species, and results in an enormous number of individuals. This commences with the division of the nucleus, a complicated and interesting process, which has been thoroughly worked out, described, and illustrated with beautiful drawings by Lauterborn. The following is a brief outline of this process. The reticulation of the nucleus becomes looser, the chromatin granules form bead-like strings, and the beads coalesce, forming bent rods called *Chromosomes.* The centrosome increases in size, and at length forms a *Central Spindle,* which takes up a position across the centre of the cell, and the chromosomes arrange themselves round its centre parallel with the axis of the diatom. They then move round through an angle of 90° to the two ends of the central spindle, and each group of chromosomes resolves itself into a new nucleus. Two new valves are formed on the central line of the diatom, and these becoming silicified, the cell-division is complete, with the result that two new frustules are formed, each containing one old and one new valve.

It has been supposed that through continued cell-division, the frustules must at length reach the smallest size compatible with the species, but if this is the case in some genera, it is by no means universal, as long flat bands or cylindrical threads are sometimes formed by repeated cell-division and the adherence together of the frustules, and these are the same size throughout. This is exemplified in species of *Fragilaria* and *Melosira,* often found in great abundance in ditches and pools.

This brings us to the question of reproduction by other means than that of cell-division. In certain species the contents of two frustules combine and form a large cell called an *Auxospore,* and Pfitzer in 1871 believed that this took place when the frustules had reached their smallest size, and that the auxospore then started cell-division as before. The fact is that this process has only been observed in a few species, but it is common in the genus *Melosira,* where chains of frustules may be found containing large auxospores as well as cells of the normal size, which, however, is very variable. Several examples of auxospores are figured in Smith's *British Diatomaceæ.*

Microspores have been observed in the genera *Rhizosolenia* and *Chaetoceros,* which inhabit the open sea, and in these the protoplast divides into 16 spores. In *Corethron,* an antarctic species, the cell-contents divide into 128 globular cells, which escape and hang about in clusters. These fuse together in pairs, increase in size, and divide into daughter-cells, which grow into diatoms. Microspores have been suspected in other genera, but *Corethron* is the only one in which the growth into diatoms has been traced. Lauterborn states that in the thousands of diatoms which he has examined he has seen no trace of spores, but hundreds of cases in which division has taken place. The writer's experience is the same. Fresh gatherings from all sorts of localities have been examined, containing diatoms of many species, large and small, but each species was of the normal size, or varying within certain limits, without any smaller forms that could be taken for immature forms of any species.

Early in the year the brown film already mentioned appears in ditches and pools, and often consists of the fully-formed bands of *Fragilaria* or the cylindrical chains of *Melosira.* What were these in a younger stage, when and where did they attain maturity and their full size, and after having been dessicated by the heat of summer, what becomes of them until they reappear in the following season ? There can be no doubt that these questions could be answered as a result of careful observation and research.

A mucilaginous substance is secreted abundantly by many, and probably by all diatoms. It unites frustules together in bands or chains by their valve faces, into zig-zag chains by their angles, forms little cushions by which the diatoms are attached

to larger plants, or elongates so as to form a simple or branched stem. In some genera the diatoms live in tubes of mucus, in others in shapeless masses or in seaweed-like fronds.

Many diatoms are endowed with the power of movement, those with a raphe being as a rule the most motile. Large *Pinnulariae* move in a slow and stately manner, while small *Naviculæ* and *Nitzschiæ* move more rapidly and by jerks, travelling for a certain distance, and then returning. The writer has seen a small *Navicula* charge into a mass of debris, adhere to it, and drag it along like a steam tug towing a haystack.

Ehrenberg, one of the pioneers of microscopical science, believed in 1838 that this movement was caused by cilia, pseudopodia, or by an undulating membrane, but no such organs have ever been detected. Naegeli, in 1849, suggested osmotic action, water being absorbed at one end and forcibly expelled at the other. Mueller, in 1889, attributed the movement to streaming of protoplasm in the open cleft of the raphe. Buetschli, in 1892, and Lauterborn, in 1894, studying the movement of a species of *Pinnularia* in water mixed with Indian ink, observed a mucilaginous filament, made visible by the particles of Indian ink, proceeding from the central nodule and elongating by jerks. They believed this to be the motive power, but Mueller considered it to be insufficient, and maintained, as lately as 1909, that the movement was due to protoplasmic currents in the raphe. The writer has repeated Buetschli's and Lauterborn's experiment with Indian ink, and has seen the particles collect and move along the raphe, form little groups at the central nodule, and then stream away in threads from the side of the frustule. The pressure exerted on the water by these mucilaginous threads is probably sufficient to cause the movement of the diatom. A very curious movement takes place in *Bacillaria paradoxa*, the frustules of which are rod-shaped and adhere to each other in bands by their valve-faces. When in motion the frustules slide along each other until they are almost end to end in long chains, and then slide back until they are as far extended in the opposite direction.

Diatoms are found as fossils in many parts of the world forming strata of considerable thickness. Freshwater deposits have been formed at the bottom of lakes, as at Dolgelly in Wales, Toome Bridge in Ireland, and Loch Kinnord in Scotland. Barbadoes earth, a marine deposit, has long been known to diatomists. A deposit at Biln in Bohemia is 14—50ft. thick, is hard and flinty, and contains, according to Ehrenberg, 40,000,000 frustules in a cubic inch. Another well-known deposit is that of Richmond in Virginia, 30ft. thick, but strata in the Western States are said to attain a thickness of 300 feet. One of the latest deposits to be discovered is that of Oamaru, New Zealand, which has yielded a large number of peculiar and interesting species. These deposits

belong mostly to the Tertiary period, but diatoms have been found in the cretaceous rocks of Paris and in the London clay. Pantocsek ascribes a deposit at Kusnetzk in Hungary to the Trias, and if he is correct, this is the oldest known deposit.

These diatomaceous rocks are useful in many ways. The hard slates of Tripoli are used for making polishing powder, Kieselguhr for dynamite, and the Bergmehl of Siberia has been mixed with flour for food when corn was scarce. To the geologist these rocks are of use in determining the conditions under which the strata were laid down, as fresh, brackish and sea-water each has its characteristic diatom flora. At the present time enormous banks extending for hundreds of miles are being formed in the Arctic and Antarctic Oceans from the diatoms which have formed plankton on the surface, have died and gradually sunk down into the depths. Careful search has been made by Cleve, the Swedish diatomist, for traces of diatoms in the Cretaceous, Rhœtic and Silurian rocks, but without results. As the oldest known diatoms appear to be as highly developed as recent species, our knowledge concerning their evolution and origin is a blank. This is another of the problems, perhaps insoluble, connected with the history of the *Diatomaceæ*.

The following works on this subject will be found in the library of the Bristol Naturalists' Society :—

"Die Bacillarien," Kuetzing (1844).

"Synopsis of British Diatomaceæ," Smith (1853–1856).

Other works containing characteristic figures of diatoms which can easily be obtained are :—

"The Diatomaceæ of the Hull District," Mills and Philip (1901), containing 600 figures

"Common Diatoms," Mellon (1920), with 400 figures of diatoms from all parts of the world.

Larger works are :—

"Atlas der Diatomaceen," Schmidt.

"Synopsis des Diatomées de Belgique," Van Heurck.

"Synopsis of the Naviculoid Diatoms," P. T. Cleve., Stockholm (1894–5).

"Untersuchungen uber Bau, Kernteilung und Bewegung der Diatomeen," von R. Lauterborn, Leipzig (1896).

"British Freshwater Algae," G. S. West (1904).

Report on the Condition of Spartina Townsendi below Clevedon, Somerset.[1]

By Ida M. Roper, F.L.S.

To start with the north-east portion of the sea front, some third of a mile long, the growth has increased this year in a marked degree. The clumps are much larger, their height is fully 3 feet, the leaves are bright green with tall flowering stems of golden hue, and the whole looks in a most healthy state and thoroughly at home in its surrounding conditions.

The outer strip of grass, which is about 100 yards out from the saltings, has completely joined together for considerable lengths, and would materially check the scour of the tides, were it not that gaps occur at intervals of one to six yards in breadth. Through these openings much mud, scoured off and set afloat from the surface behind, can make its escape as the tides recede, and so little advantage is as yet secured in the main purpose of the experiment. In place of the original three bands stretching in towards the bank there are now five, of some 10 yards width and 40 yards length, and these have become of so close a formation as to resemble miniature meadows, the effect of which must retard the scour. At the western end of the outer strip a similar sized meadow of grass stretches seawards and helps to check the slower tides, but would be of small help against waves, as it is submerged soon after flood tide starts to flow.

As mentioned, the numerous scattered clumps nearer the land are healthy and larger, but from their isolation do not at present avail against the swirl of the moving water.

With growth maintained equal to the present season, it will be some years yet before the inner mud shore will be covered over completely with a surface of Spartina ; a fresh and thick planting of the grass there would be likely to hasten materially such covering.

The owner of the grass fields behind this portion of the shore anticipates, however, no ultimate success for his experiment, and whatever happens, in order to save what is left of the saltings, he is having a stretch of strong walling erected against its upright face. With the foundations put well down, the mud protecting them should remain a sufficient support till the growth of the new surface of Spartina comes fully into effect. More stable conditions should follow and the chief purpose of the experiment be successful.

Examination of the western stretch of shore, some mile in length, does not give an equal satisfaction. For a long distance there are only three solitary clumps of Spartina left, as the

1. See Vol. v., p. 46.

remainder have been washed away. As previously reported the trial in this one-third of a mile was a failure from the start, as the heavy waves carried off nearly all the planting. It is here the two breaches in the seabank occur and these are again wider and deeper, and must cause anxiety and compel repairs.

Then follow the three small bights, within the shelter of which the Spartina holds its position, much the same as a year ago. The scattered clumps are larger, but remain under two feet in height with poor flower heads and a general lack of vigour, as compared with those to the north-east. In their turn they may become vigorous, but for the present they can have no effect to check the removal of the mud surface. The wash of the tide swirls completely round each clump and keeps the top of the mud outside them nearly an inch below the point whence the rootlets spring, so that these have to grow downwards to reach cover and are exposed during the time to the cold of the nights and liability to breakage. This appears to check the spread from the outer plants of the clumps, and it must be chiefly those within that add to the increased size. This check was noticeable in comparison with one clump amidst sand, which had runners six inches long with numerous rootings from the nodes.

It may be that the bights do not supply the optimum for Spartina growth, and the natural vigour of the plants, helped by the shelter from the heavy waves will require extended time to flourish.

The last half of this section to the westward has also suffered much by washing away of the clumps, and only a small number remain scattered along its length.

There is promise of a good crop of seeds on the northern section, to judge from the profuse flowering, but the plants are too far out to inspect, and even if produced and fertile the tides will carry the seed away. There are no clumps started from the seed of previous years in the wide expanse of mud on the seaward side of the established strip.

The experiment made on this exposed and tide-swept shore seems to require patience and time for the plants to grow into close formation. For quicker results, closer planting at the start should be followed, or fresh plants put in at intervals, so that when they have grown to clumps their presence can help the older ones to enlarge more rapidly by the survival of shoots from the outer edge as well as from within.

Bristol Botany in 1919.

By Jas. W. White, F.L.S.

The notes recently supplied by local field-botanists contain a remarkable number of references to malformations or irregularities of growth and development among wild plants of the district. At one time exceptional deviations from normal rules were regarded as monstrosities, mere objects of curiosity unworthy of scientific attention. But during the past century contributions to the history of these abnormal growths have been made by many eminent botanists who endeavoured to trace the causes producing them, and to fix the limits between variation and malformation. He who wishes to study the subject can now have the assistance of several excellent books. In systematic order the observations are as follows :—*Anemone nemorosa* L. with double flowers (*Roper*). *Rubus rusticanus* Merc., inflorescence on barren shoot of the year, a recognised form of phyllody (*Roper*). *Bellis perennis* L., phyllaries and florets all tubular and virescent (*Sandwith* and *Gibbons*). *Linaria spuria* Mill. showing an approach to peloria (*Sandwith*). *Digitalis purpurea* L. cult. with calyx, corolla and stamens all changed into closely ranked leaves with an ovary terminating each pedicel (*Bucknall*). *Stachys sylvatica* L., flowers virescent (*Sandwith*). *Euphorbia amygdaloides* L., had a thick cluster of leaves above the flowers (*Roper*). *Orchis mascula* L., sepals and labellum suppressed (*Roper*). *Listera ovata* R.Br., spike forked (*Gibbons*). *Typha latifolia* L., spike bifid, but re-united at the tip (*Roper*). *Lolium italicum* A. Braun., spike panicled (*Gibbons*). But attention has been particularly attracted by abnormal flowering stems of the Archangel (*Lamium Galeobdolon*) noticed in two places in Leigh Woods by Messrs. Gibbons and Sandwith, and in two at Failand by Miss Isabel Worsley and D. Williams. In the more conspicuous variations of the plant there is a peloria apparently seated on the apex of the stem—an erect, almost regular flower with long protruding stamens. This peloria seems always to be accompanied by a tiny bud, which is probably the growing point of the primary axis, and therefore it is not really terminal but axillary, as all the flowers of an indeterminate inflorescence should necessarily be. (See Worsdell, *Pl. Teratology*, vol. ii., p. 149). Miss Agnes Fry, who carefully examined a number of these peculiar plants, found the peloria to be very variable and not representing a return to one type. None of them was really quite regular ; the sepals might be 2, 3, 4 or 5 ; the petals 3, 4 or 5 ; and the stamens 3 or 4. Indeed the parts all showed evidence of confusion, that is to say the floral leaves tended to be sepaloid, the sepals to be petaloid, and the petals to be staminoid. This occurrence, however remarkable, is no new thing. In Withering's *Arrangement of British Plants*, ed. vii., 1830, p. 713, Sir John

Cullum's mention is quoted of "a curious and elegant variety [of Archangel] with the blossom, or at least the terminal flower, flat and six-cloven, growing for many years (first noticed in 1774) in a lane near the Grove at Hardwick, not far from Bury." It will be seen that this notice indicates that the plant described came true season after season. In the third edition of the same work, 1796, vol. iii., p. 529, a var. 3 of *Galeopsis Tetrahit* is thus described :—"Terminating flower always salver-shaped and regularly 4-cleft, with four equal stamens, while all the rest had their proper form. Found by Dr. Smith at Matlock in 1788." As to the causation of these sports we are entirely in the dark. Insect agency has nothing to do with it as no distortion of a gall nature can be detected ; and we can hardly suppose that a cold set-back after an early spring that might produce some impoverishment would be responsible for the changes described.

From the abundant observations reported on our scarcer Bristol plants it is regretted that a selection must be made, space not being available for publication of the whole.

Ranunculus sardous Crantz. Marshy field south of Bristol, in considerable quantity ; *Dr. Newman Nield.* *R. Lingua* L. Springhead near Nailsea, S. ; *H. J. Gibbons.* It is now known that the glabrous form of this species (*R. Lingua*, var. *glabratus* Wallroth) exists in Britain, and Miss Roper suspects that the Bitton withybed plant may agree with the description : "Caule, calycibus foliisque utrinque glaberrimus." Collectors should search for the variety among their herbarium specimens.

Berberis vulgaris L. Border of wood above the Frome at Frenchay, G. Hedge at Compton Dando, S. ; *Ivor Evans.* Two bushes near Warleigh Ferry, S. ; *H. T. Green.* The fine bush in Markham Bottom has flowered sparingly of late.

Papaver Lecoqii Lamotte. Between Woodlands and Almondsbury, G. and near Chapel Allerton, S. ; *Noel Sandwith.*

Radicula pinnata Moench. Mill-pond, Frampton Cotterell, G. Rare in the county ; *Miss Roper.* Bank of the Chew near Keynsham, S. ; *H. T. Green.*

Armoracia amphibia Peterm. A little on the peat of Burtle moor, S. ; apparently a first record for the peat-moors ; *Mrs. Sandwith.*

Viola hirta, f. *imberbis*, Berwick Wood, Hallen, G. ; *Miss Roper.* *V. hirta*, f. *nudicaulis*, Asham Woods, Frome, S. ; *Id.* *V. hirta*, var. *propera*, Cadbury Hill, Yatton, S. ; *Id.* *V. Riviniana* × *silvestris*, under Lansdown, G. ; *Id.* *V. odorata* L., var. *subcarnea*, Quarry near Wickwar, G. ; *Noel Sandwith.*

Hypericum dubium Leers. Field-border by Clack Mill, Westbury, G.; *Roper.* Edge of a wood between Failand and Easton-in-Gordano, S.; *Rev. E. Ellman.* *H. montanum* L. In unusual quantity on the Cadbury ridge above Clapton Wick. Churchill Batch, S., very sparingly; *Mrs. Sandwith.*

Geranium pratense L. Meadow at Westbury, S.; *Mrs. Sandwith.* The nearest locality to this in *Fl. Brist.* is at Draycott.

Lotus tenuis W. & K. Salt marsh below Shirehampton, G., confirming the old records in *Fl. Brist.*; *Noel Sandwith.* Near Almondsbury; *Id.*

Rubus Bakeri F. A. Lees. Rodway Hill, Mangotsfield, G.; *Roper.* An addition to the Bristol flora. *R. villicaulis* Koehl. Highbury Wood, Hallatrow, S.; *Id.* *R. Kaltenbachii* Metsch. Cutting the timber in Leigh Woods has shown this fine bramble to be even more widely spread than was believed.

Pyrus cordata Desv., var. *Déséglisei* Rouy and Camus. A new locality for this interesting pear has been found half-a-mile or so north of the original station (*Sandwith*). Two large trees grow on the edge of an ancient track and pasture. The wood in which the pear was first noticed was unfortunately cut down during the war; this discovery is therefore doubly welcome.

Peplis Portula L. Pool, Lyde Green, G.; *Roper.*

Sedum Telephium L. Lane between Tyning's Farm and Charterhouse-on-Mendip; *Sandwith.*

Daucus gummifer All. The Rev. E. Ellman, who is well acquainted with the genus, considers some plants on Brean Down to be the true *gummifer.* Other coast Carrots whose leaves are not dark green and shining, but which, in early flower at any rate, do match Withering's drawing of his *D. maritimus,* will in future be well placed under the var. *intermedius* of Corbière. In support of its grade as a distinct species experiments made on the Dorset coast have shewn that seedlings of *gummifer* come true with great uniformity.

Sambucus Ebulus L. A new locality near Keynsham, S., has been reported independently by Messrs. Bucknall and Ivor Evans.

Valerianella carinata Loisel. Continues to appear in the Clevedon locality; *Miss Livett.*

Inula Helenium L. By a stream at Stone, G.; *Sandwith.* In a paper "On the Home of *Inula Helenium,*" published in the *Journal of Botany,* Mr. C. C. Lacaita states that Elecampane has been cultivated for the properties of its root in sundry parts of Europe from time immemorial, and so has become established

as a naturalised alien in many regions where it has no claim to be indigenous. Such, for instance, are Great Britain, Northern France, the Low Countries, Germany, and Scandinavia. The plant is unquestionably native only in Southern Italy, Spain, Greece, and Macedonia. These facts should be of particular interest to us who know the handsome *Inula* in so many localities.

Menyanthes trifoliata L. Spring-head near Nailsea, S. ; *Gibbons.*

Orobanche elatior Sutton. Mr. T. H. Green reports this to continue yearly on oolite above Weston, Bath. The locality may well be the one recorded in *Fl. Bathon.*, and by the late J. G. Baker in 1884.

Mentha piperita L. Near East Harptree ; *Salmon* in *Fl. Som. Suppl.* Roadside ditch near West Harptree ; *Sandwith.* Peat moor near Shapwick Station, repeating Clark's record of 1857 ; *Id.*

Salvia pratensis L. One plant in a field of mowing grass on Hampton Down, Bath ; *Sandwith.* A typically casual occurrence of this plant in the West Country.

Atriplex rosea L. On a Corporation rubbish-tip at Eastville, G. Although an annual the plant formed a strong, shrubby bush three feet or more in diameter. Its determination was effected by Messrs. A. J. Wilmott and W. C. Barton, who compared specimens with those in *Herb. Mus. Brit.*

Orchis ustulata L. Among some papers at Taunton Castle there has been discovered by Dr. Downes a "List of the Rarer Plants of Somersetshire," by the Rev. C. Parish, 1850. The list contains most of the more noteworthy species known to grow in the county, and in some instances gives localities unmentioned in the *Flora of Somerset* or its *Supplement.* Mr. Parish lived at Staple-Fitzpaine, south of Taunton. His explorations, however, extended to the northward, and he records the Burnt-stick Orchis as having occurred at Churchill, Mendips, an additional station for this scarce and beautiful species.

Ornithogalum umbellatum L. Mr. T. H. Green finds this still existing near Combe Hay, whence it was recorded by Dr. Davis in *Fl. Bathon.*, 1834.

Juncus tenuis L. One tuft in open woodland, Failand, certainly introduced ; *Sandwith.* Another tuft in Water Lane, Portbury, S. ; *Roper.*

Eriophorum polystachium L. was recorded in *Fl. Brist.* from Max meadows, Winscombe, on the authority of Theo. Compton. Miss Roper now says that the only Cotton-grass she can find in the locality is *E. latifolium* which had not been previously reported from Max.

Schœnus nigricans L. Boggy meadow, near Churchill, S. ; *Roper.* Discovered in fair quantity on the peat of Shapwick Moor

near the large patch of *Cladium* by Miss Roper and H. J. Gibbons. Another instance of the inexplicable way in which conspicuous plants escape observation on the Turf Moors of N. Somerset. There is no previous record of the occurrence of this sedge in that district.

Scirpus sylvaticus L. Has reappeared plentifully at the Boiling Well, G. Glastonbury Moor, in a swamp on the north of the railway! T. H. Green reports it also from the south of Ashcott Station.

Carex acuta L. Itchington Moor, G.; *Roper.* Marsh by the road between the Leech Pool and Bury Hill, G.; *Bucknall.* Several tufts by the Avon at Twerton, S.; *Green. C. xanthocarpa* Degl. Nailsea Heath, S.; *Ellman* and *Bucknall. C. pseudo-cyperus* L. Spring-head near Nailsea; *Gibbons.* By Wurple Pool, above Barrow Gurney, S.; *Sandwith.*

Holcus mollis L. Glen Frome, G.; *Sandwith.* On Mendip near Charterhouse, S.; *Id.* The Watchetts, near Wells; *Id.* Lane near Portbury; *Roper.*

Elymus arenarius L. This handsome but elusive grass has been on record from our shore of the Bristol Channel since early in the last century, appearing from time to time in various places between Clevedon and Burnham, but never remaining long in the same spot. If we assume that Dr. Moss did find it during his ecological examination of North Somerset, as his published work seems to indicate, it may be about fifteen years since the plant was last reported. Now Mrs. Sandwith has handed me a specimen found last September on the shore near Burnham.

Polypodium vulgare L. var. *serratum* Willd. Still at Cheddar, where it was noticed by H. C. Watson some eighty years ago; *Sandwith.*

Nitella translucens Agardh. A new plant for the county of Somerset, discovered on the Glastonbury peat moors by Mrs. Sandwith. The moors were said to be strangely barren of Characeæ until this botanist proved that the stigma was entirely undeserved.

ALIENS.—*Sisymbrium hispanicum* Jacq. *Fl. Brist.* p. 149. Dr. Druce informs us that this casual from St. Philip's Marsh was really *S. Volgense* Bieb. teste Prof. Thellung. The North American Asters, so abundant in our gardens, form a most difficult group and their nomenclature is singularly confused or discordant. The plant established on Hawkesbury Hill and queried in *Fl. Brist.* for *A. Novi-Belgii* L. has since been named on authority *A. lanceolatus* Willd, with a train of four synonyms conferred by Continental botanists. An *Anthemis* from St. Philip's Marsh, closely allied to *A. arvensis*, has lain unidentified since 1904. It has been lately determined by Dr. Thellung as *A. Wiedmanniana* Fisch. & Mey., a native of Asia Minor. Numerous other adventives collected on Bristol rubbish-tips are catalogued in Dr. Druce's Secretarial *Report of the Bot. Soc. Br. Isles*, a mine of botanical research and information.

Some Geological Studies at Clevedon, Som.

By Edward Greenly, D.Sc.; F.G.S.

Contents:

I. The Carboniferous Rocks.

Repetitions of the *Cleistopora* Zone. The great section on Clevedon Beach is now well known, though, being all on low foreshore, the shales which lie between the thin limestones are often concealed by mud and shingle. But in February, 1920, their upper beds were wonderfully laid bare near Breakwater Tank, about 80 feet of green and purple shale, interrupted by only one or two thin bands of limestone, being then visible. These K-beds pass under massive limestones of Z rich in *Spirifer* aff. *clathratus*, and an ascending succession of the members of the zone of *Zaphrentis* (including γ) has hitherto appeared to follow, without a break, to the base of the *Laminosa* Dolomites of the southern dip slopes. The outcrop is indeed suspiciously wide, being more than 500 yards, whereas at Castle Lodge, Walton, where the average dip is about 6° lower, it is only some 300 yards. In January, 1920, however, after heavy storms, my friend Mr. Gray Usher, a young and enthusiastic student of the local geology, discovered that the sea, sweeping away the shingle, had revealed on the floor of Littleharp Bay some 70 feet of green and purple shale, with thin compact limestones, which he rightly referred to the K-beds, remarking moreover that the massive limestones which rest upon them were rich in a *Spirifer* which he thought must be *S.* aff. *clathratus*. A little later on, I found that about 100 feet of the same shaly series, overlain by similar massive *Spirifer*-limestones, had been laid bare on the foreshore of Salthouse Bay as well. A search for the zonal fossil of K was unsuccessful. But in February, 1920, I had the advantage of showing the section to Prof. Sidney Reynolds, who not only concurred in recognising the shales as those of the K-beds, but detected *Cleistopora* aff. *geometrica* in one of the thin limestones of Littleharp. At the same time he confirmed the identification, in each case, of *Spirifer* aff. *clathratus* in the overlying massive limestones. The horizons are thus placed beyond all doubt. The abnormal apparent width of outcrop receives an explanation, and it is clear that the upper portion of the K-zone, with the base of that of Z, is brought up twice over. The beds are considerably

disturbed, and the nature of the disturbances at Littleharp leaves no doubt that the ruptures are true over-thrusts.

The *Caninia*-dolomites. These have not been hitherto recognised at Clevedon, but a few feet of their "china-stones" must rest upon the oolite of the steep dip slope in the woods east of Hillside Lodge, just before the limestone series is cut off against the Coal Measures by the Woodside fault. The exposures are now utterly overgrown, but the débris has been identified by Prof. Reynolds, to whom I shewed the section.

II. The Triassic Rocks.

The *Keuper Marls* have been seen only in two small and poor sections ; one in the bank below B.M. 72.4 on the Highdale road, the other in the garden of a shop at "P," close to Clevedon Triangle. They are of importance, however, as evidence that these marls really underlie the Pleistocene sands of the gentler slopes and the alluvium of the plain. Beds of red marl, a few inches thick, lie between the conglomerates on the coast. There is also probably a Triassic bay at St. John's Church and Queen's Road. It is not, apparently, exposed, but the evidence of the features is decidedly in favour of its existence.

The *Conglomerate* is generally the characteristic breccia with angular blocks of Carboniferous Limestone in a reddish yellow dolomitic matrix with grains of clastic quartz. Where it rests upon the Old Red Sandstone the blocks are mainly of that rock, and at the Pier they attain 2 feet in diameter. But the formation is at Clevedon even more variable than usual. At Stancliff and near St. Mary's Church (Walton) it is a massive yellow dolomite with only an occasional pebble, sometimes with none at all, and yet is often false-bedded. At Stancliff, galena (mentioned by Reynolds) rises to the rank of a rock-forming mineral. The texture is not compact but phenocrystalline, and specimens often closely resemble the Magnesian Limestone of Yorkshire. The rock is usually full of little cavities in which minute crystals of barytes (and perhaps of celestine) may be detected. In the Fir-wood, the usual ruddy breccias are overlain by a yellow dolomite which has a finely oolitic texture. Prof. Sidney Reynolds, to whom I sent a specimen, writes me that he has had a slide cut therefrom which shows oolitic texture well developed. Thus oolitic limestones of widely separated ages occur close together at Clevedon.

New Records of the Conglomerate.—A small outlier, hitherto unknown, has been detected in the woods 100 yards to the south of Woodside. It is a typical Dolomitic Conglomerate with pebbles of limestone. On the Old Church Headland (at Salthouse Point and Wain's Hill) two more small outliers appear to be present,

though as the Carboniferous rocks are locally dolomitized there is some uncertainty as to whether there be really patches of Triassic dolomite upon them. To the west of the Old Church the Trias has now been found to extend right up to the edge of the sea-cliff.

Exposures of the Base.—On account of the remarkable unconformity these are always of interest. The junction is laid bare at the Pier, and also on the foreshore a few yards to the south. On Ladye Bay cliff the conglomerate can be seen to pass upward across the edges of the steeply inclined Old Red Sandstone, and though the actual junction-plane is obscured by vegetation on this cliff, it is admirably exposed in a cave just beyond Ladye Point. On the path at the south end of Stancliff quarry, the Triassic dolomite, which dips gently seawards, is seen to rest directly upon shale and thin limestone of the K-beds, dipping steeply landward, but this interesting little section is only a yard or two long and barely a foot in depth. The K-beds also reappear in the floor of the quarry. At the lower end of the road on the western edge of the Fir-wood, the conglomerate can be seen resting in a hollow of the surface of steeply dipping Z-limestone, and at the edge of the sea-cliff west of the Old Church, where pebbly dolomite again rests on Z-beds, its base is once more laid bare. Finally, in the woods above the Court Farm, there is a clear junction with *Caninia*-oolite. Thus, in quite a small tract, the Triassic base passes across every Palæozoic formation from the Old Red Sandstone to the C-beds, and its junctions with the Old Red, the K-beds, the Z-beds, and the *Caninia*-oolite are laid open to view. The great irregularity of the sub-Triassic surface will be considered in connection with Tertiary erosion.

Disturbances.—The formation rests, for the most part, at very low angles, but along the coast there are north-westerly dips of 7°-20°, and a low south-easterly dip is discernible in the Fir wood. The exposures of the base indicate that this is mainly a deposition dip. Yet there are some disturbances. On the Walton Cliffs there is a gentle anticline which ends abruptly at Ladye Bay in a fault (well exposed at the foot ot the steps) which brings the Trias conglomerate against the Old Red Sandstone with a downthrow to the south of about 100 feet. A fault also runs in from the sea near the Friary, but it seems to be very small. The Ladye Bay fault plainly determines the feature which crosses the ridge under Walton Castle and the notch at Holly Lane, but it appears to have almost, if not quite, died out before the eastern end of the notch is reached.

III. Holocene Deposits.

The Alluvium of the Plain.

Sections to the depth of 5-6 feet are laid bare along the rivers called the Land Yeo and Middle Yeo, as well as in the brickyard

on the Strode road. They reveal a bluish grey silt or clay covered sometimes, along the Land Yeo, by a reddish clay. These deposits are full of shells, and along the Land Yeo between East Clevedon and Clevedon Court, have yielded the following forms, which have been kindly determined by Mr. E. T. Newton and Mr. A. S. Kennard.

Limnoea pereger *Müller.*
Planorbis umbilicatus (*Müller*)=marginatus (*Drap.*)
Planorbis vortex (*Linn.*)
Planorbis albus (*Linn.*)
Paludestrina jenkinsi (*Smith*) *
Valvata piscinalis (*Müller*).
Bithynia tentaculata (*Linn.*)
Pisidium amnicum (*Müller*).

The upper 6 feet therefore, at any rate, of this alluvium are of purely fresh-water origin, but as the average level of the surface is 20 ft. O.D. there are still 14 ft. of unknown character above Ordnance Datum. There is much indeed yet to be ascertained concerning the deposits of these great plains, known locally as "The Moors." They are well worthy of investigation, for they are, next to the East Anglian Fenland, the largest alluvial tract in England, constituting really a Fenland of the West. Their relations to the marine "Burtle beds" on the one hand and to the "Submerged Forest" on the other, of their lower beds have yet to be discovered.[1] For this purpose open sections are not likely to be available and records of well sinkings should therefore be carefully examined by local geologists.

IV. THE LAND-SURFACE.

Pliocene Erosion.

That the existing land-surface must be a development of Tertiary (not of older) time is evident from the distribution of the Mesozoic rocks, and from the proximity of the chalk escarpment. In the light of recent researches,[2] then, we naturally look for some signs of one or more of the Pliocene platforms at levels of about 275, 430, and 550 feet, which have now been recognised along various parts of the western sea-board. None of them, it must be admitted, have yet been recognised with certainty at Clevedon itself, or in the

1. At Shapwick, near Glastonbury, gravel, sand, clay and peat were pierced to a depth of 61 feet. [W. Bidgood, Proc. Som. Arch. Soc., xxvi. (pt. 2), p. 126].

2. "The Geology of the Lizard and Meneage," (Mem. Geol. Surv.), pp. 1–3, 229–31. Also "The Geology of Anglesey" (Mem. Geol. Surv.), pp. 779–84; and "The Origin of some Land Forms in Carnarvonshire," by H. Dewey, Geol. Mag., 1918, pp. 145–57, and other publications.

* Mr. Kennard remarks that the occurence of *Pal. jenkinsi* in these deposits goes to confirm the view that it is a true native.

extensive prospect visible from Dial Hill. Nevertheless, it may be more than a coincidence that the average level of the high land overlooking the town is about 275 feet, which is the average level of the Menaian platform of Anglesey.[1] But whether definite planes of erosion be eventually recognised here or not, the measures of subsequent sub-aerial erosion recently made available in Cornwall and North Wales enable us to assign the excavation of the Clevedon valleys, with considerable confidence, to the latter part of the Pliocene period. While, on the other hand, it is certain, from the distribution of the Holly Lane sands and breccias that they had been excavated to somewhat more than their present depth before the Pleistocene period had passed away.[2]

The *sea-cliffs* present an interesting feature. If standing near the Pier we look at the Old Church Headland, which is about 120 feet in height, we see that its north-western face is divisible into two perfectly distinct portions. The lower part is a vertical crag 50-60 feet in height, but the remainder is a grassy escarpment with a slope of about 35-40°. Clearly the latter is the work of subaerial erosion, and the present composite outline is manifestly due to marine erosion which has cut back into the foot of the old escarpment. Now, when the oldest of the "Forest-beds" were flourishing[3] the land must have been 55 feet higher than it is to-day, and the sea could not have had access to the foot of that escarpment. Some of the sea-cliff may have been developed at the period of the Weston and Woodspring Raised Beach, but the present form of the headland must be due to marine erosion that has been made possible by the subsidence which has let down the forest-beds.

V. Pliocene Restoration of the Triassic Land-Surface.

Conditions Necessary to Restoration.

The land-surface is of especial interest, however, from the remarkable degree to which Pliocene erosion has reproduced for us the actual features of a long buried land-surface of Triassic times.[4] Ancient land features can be inferred sometimes from the phenomenon of overlap. In rare instances only are they actually visible,

1. Durdham Down at Bristol, long recognised as a plain of marine erosion, is at about the same level. May it be after all a fragment of the same platform?
2. *Greenly, E.* Proc. Geol. Soc., Dec. 8, 1920.
3. *Strahan A.* 'Submerged Land surfaces at Barry, Glamorganshire,' Q.J.G.S., vol. lii. (1896), p. 483.
4. This was the subject of one of the present writer's earliest papers "A Triassic Land-Surface," Edin. Geol. Soc., 1894, and in 1898 it was enlarged upon by Prof. Lloyd Morgan in the British Association Handbook for the country round Bristol. The phenomenon is evident in the horizontal sections of the Geological Survey, but is not mentioned in the Bristol Memoir.

as in the extraordinary case of the Sub-Torridonian surface of the North-West Highlands[1] and some others that are not quite so striking. More rarely still is an ancient landscape disinterred by erosion and reproduced over any considerable tract of country[2]. To give us this result certain special conditions must be combined. The ancient valleys must have been filled in with a deposit which would yield to Tertiary erosion much more rapidly than the rocks whereof the ancient ridges are composed. These deposits must remain horizontal or at any rate but very slightly disturbed, and thirdly, the ancient and the modern base-levels of erosion must differ but little from one another. In northern Somerset all these conditions are combined, but only in a tract of a few miles in width. For, owing to those movements of early Tertiary date, which have imparted a gentle south-easterly dip to most of the Mesozoic rocks of England, the block submitted to early and mid-Tertiary erosion was worked upon in a slightly inclined position. To the north-west of our area the Triassic base-level has been raised above that of the surface of the Pliocene platform, and has been swept entirely away. To the south-east it has been let down so that the Rhaetic beds are at the present level of the sea. Within our area the Triassic is a little below the Pliocene and present base-levels, and the general south-easterly dip is so low as to be imperceptible in the width of most of the re-developed valleys.

History of the East Clevedon Gap.—In this paper our concern is only with the restoration of the Triassic features of Clevedon itself, one of which however is unusually impressive. First noting that whereas the Triassic base is at no less than 260 feet O.D. at the Walton Castle outlier, it is, at Clevedon Triangle (p. 139) at an unknown depth below the 20-feet level, we will proceed to consider the age of the great chasm which we may call "*East Clevedon Gap.*" This precipitous and craggy notch is about 250 feet in depth, and only 450 feet wide between the feet of the crags at the Smithy. Do we see even here a re-excavated feature of Triassic times ? On both Sanders' and the 1-inch maps, its floor is represented as occupied by the Keuper marls. No exposure of these, however, has been found ; there is no remark upon it in the Bristol Memoir, and a suspicion arose that the maps had been based on the evidence of the features alone. Positive evidence was much to be desired. The first that was forthcoming was the discovery of the little Woodside outlier, which, with its bedding horizontal, clings to the crag-side at the level of 130 feet, just within the northern entrance to the Gap. That nevertheless, left it possible to assign 130 feet of deepening in Carboniferous rocks to Pliocene erosion. Now,

1. "The Geological Structure of the North-West Highlands of Scotland," Mem. Geol. Surv., pp. 275–7.

2. The similar and contemporaneous case of Charnwood Forest has been admirably described by Prof. Watts (Geograph. Journal, 1903) and other publications.

however, a narrow rim of Dolomitic Conglomerate has been found at the back of the cottage gardens on the eastern side, clinging to the foot of the Carboniferous crags in the low ground along the very middle of the Gap. These two pieces of evidence demonstrate that even East Clevedon Gap was excavated by Triassic erosion, then completely buried in with deposits of that age and re-excavated by Pliocene erosion.

That the ancient features have been modified may be freely admitted. Probably the brows of the crags have retreated a little in places, but the surviving fringe of conglomerate along their feet shows that their lower parts were steeper then than they are to-day. A short distance outside the south end of the Gap, in the woods above Court Farm, a curious circumstance enables one to make a rough estimate of the gradient on the dip-slope side of the ancient ridge. The Trias conglomerate reposes here against *Caninia*-oolite, but not a single fragment of that oolite was found in it. Every block seen was derived from the *Laminosa*-dolomites, which outcrop higher up the hill. Plainly these blocks of dolomite are Triassic scree-material which slid down from above ; and, from their abundance, and the completeness with which they have masked the oolite-crag, they must have moved with considerable freedom. In other words, the angle of the slope down which they came could not have been less than their angle of repose. Now, the blocks are of moderate size, and the angle of repose for such material varies between 30° and 40°, which gives a lower limit for the gradient. On the other hand, that gradient could not have exceeded the angle of dip of the Carboniferous rocks, or the *Laminosa*-dolomites could have had no outcrop on the dip-slope. The dip in question is about 45°. So a mean of the upper and lower limits indicates a gradient of somewhere between 38° and 40° for the upper part of the southern slope of the Triassic ridge.

The Pleistocene Formations of Claverham and Yatton.

BY EDWARD GREENLY, D.Sc. ; F.G.S.

LIMESTONE GRAVEL.

Over a wide tract in the Claverham country, a coarse limestone gravel comes down from the hills, apparently for the most part from the Cleeve Combes. In Plunder Street Combe (the only one I have mapped) it has not been seen, but appears at the mouth, and spreads out at once over the lowlands, resting upon the Triassic marls, and passing under the great alluvium. Its thickness is unknown, the deepest section seen being only four feet. The best exposures yet observed are at Streamcross and Claverham Farm, but there are numerous minor ones. No fossils have been found, for certain specimens of *Planorbis* and *Helix*, which cling to the faces of shallow pond and hedgerow-sections, appear to be recent and extraneous, none of them having been obtained from within the deposit.

The gravel has usually a matrix of clay, sometimes faintly red, as if partly derived from the Triassic marl, and is not loose but semi-consolidated. It is scarcely stratified if at all. The pebbles, which are almost all of Carboniferous Limestone (with a few of red sandstones and some hard chert-like rocks), are usually about three inches, though often attaining to six inches, in diameter. They are but rudely rounded, sometimes hardly more than sub-angular, and frequently show concavities of surface, which though somewhat rough, may be as well smoothed as the convexities, like stones in boulder-clay often are. Where the base is visible, the gravel rests upon an eroded and uneven surface of Triassic marl, which, with its thin hard bands and veins, is broken down to a mere clay-with-stones. The sheet of gravel, whose surface is broadly undulating, may occur at all levels between the 100-foot contour and the margin of the great alluvium, but is absent on the summits of one or two of the eminences of the lowland. It crosses the 50-foot contour abruptly, and may mantle one side of an oval hill, but not the other side. In short, its distribution is quite independent of the drainage-hollows of to-day, nor is there any stream which could have brought it down from the hills. It could not have accumulated under existing conditions. But the limestone highland of Cleeve is hardly 20 miles from the margin of the glaciated areas across the Channel, so that, while no true glaciers appear to have been formed on them or on the adjacent Mendips, heavy snow caps, perhaps even ice caps, must surely have been formed in winter. To their summer melting floods we may reasonably ascribe these gravels.

THE DRY LIMESTONE COMBES.

Closely connected with the origin of these gravels is that of the deep limestone combes, whose floors are so frequently streamless, owing to the cavernous nature of the limestone, which allows the water to sink into subterranean courses, such as have been proved to exist at Burrington. Under existing physiographical conditions these deep combes could not have been formed. They could only have been formed in the course of the Tertiary period, when the limestone ridges were still mantled round by impervious Mesozoic rocks. The saturation-level of the limestone would then be as high up as the surface of the mantling Keuper marls, gradually lowering as the stream cut its way down through those deposits. The marls, in fact, holding up the saturation-level, would enable the water to cut out combes in the limestone. But there is every reason to believe that in the Pleistocene period, the physiographical features differed but little from those of the present time. How, then, could these masses of gravel have been swept out of Cleeve and other combes? An answer can be found, I think, if we apply the principle by which Reid and Spurrell[1] have accounted for the origin of dry valleys in the chalk. It is well known that in Arctic Siberia the subsoils are perennially frozen to a depth of 60 or 70 feet, the summer thaw being merely superficial. During the Glacial Period, similar conditions must have prevailed over large parts of southern England, which was not protected by an ice sheet. Under these circumstances, the Carboniferous limestone would be frozen to considerable depths, and would become impervious to water. Any rainfall of summer, and the whole of the melting water of the snowcaps, would, instead of sinking in, run off immediately, as violent and transitory torrents in the steep combes. Rubble which had been loosened by frost and summer thaw would be swept rapidly out of the combes and deposited as fans upon the lowlands just outside, with such force as to over-ride their minor undulations, and this is precisely the distribution of the Claverham gravels.

SHATTERING OF THE TRIASSIC BEDS.

Around the slopes of Cadbury Hill near Yatton,[2] and along the low Yatton ridge, the Triassic marl, here containing thin beds of sandstone and dolomite, as well as veins of calcite and gypsum, is excessively shattered. The bedding is destroyed, and the fragments of the harder beds and veins are rudely rounded, so that, kneaded into the matrix of marl, they constitute a sort of red clay-with-stones. The best sections are in the roadside cuttings at Rhodyate and Frost Hill, and in Yatton railway cutting just

1. Quart. Journ. Geol. Soc., 1887, pp. 364–371.
2. To be distinguished from Cadbury Camp near Clapton-in-Gordano.

under the bridge, but the phenomena are to be seen in many other places. The Rhodyate section was quite clear in the summer of 1917, but may be expected to deteriorate. In it and at Yatton the stony clay can be seen to a depth of some 10 feet, graduating down into the shattered surface of the Trias. Nearer the hills, where the Trias is more sandy, it passes into a stony sand. One or two stones are faintly striated, there are fragments of hard ferruginous cherts which have not been seen in situ, while a small piece of Carboniferous Limestone, somewhat smoothed, was found as far west as Yatton cutting. In fact, the formation recalls the true boulder-clays, but the extreme rarity of striated stones, the feebleness of the striations, and the almost total absence of erratics, forbid us to regard it as such. It also recalls the descriptions which are given of the 'Trail' of Southern England, and of the 'moving stony muds' of sub-arctic regions, which glide and flow during the thaws of summer. If we suppose that, during the Glacial Period, the Triassic marls with their thin hard bands were shattered by frost expansion and then set free to glide by the summer thaws, we seem to have some clue to the origin of this formation. When gliding, the fragments of the hard beds could be driven into the moving marl, and occasionally rubbed and scratched against each other. The scanty fragments of Carboniferous Limestone might have been brought from the Claverham gravels (which have been traced to within two-thirds of a mile east of Yatton Bridge) frozen into ice coming down with the summer torrents which deposited those gravels, and floating across the hollow now occupied by the Yatton and Claverham alluvium. But the phenomena, as do those of the gravels, call for further investigation.

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J. W. Tutcher, 1921
Mrs. Vaughan, 1921
E. A. Wilson, 1920-1
H. Womersley, 1921

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List of Members, December, 1921.

A Associate Member. † Life Member.

* Has contributed Papers to the "Proceedings."

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	Blood, B. N., M.D.	5, Brynland Avenue, Bishopston
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A	Brebner, Mrs. G.	22, Victoria Road, Cotham, Bristol
	Brittain, Col. R.	Failand Hill, near Bristol
	Carter, Miss F.	14, Charlotte St., Park St., Bristol
	Cay, Arthur	Lyndhurst, Leigh Woods, Bristol
	Chamberlain, W.	51, Oakfield Road, Clifton
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	Cook, Mrs. E. H.	27, Berkeley Square, Bristol
	Cooper, J.	43, Station Rd., Ashley Down, Bristol
	Cottle, A. W.	Black Horse Hotel, Kingswood, Bristol
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	Darbishire, Prof. O. V., Ph.D....	The University, Bristol
†	Darell, D., F.G.S.	Hillfield House, near Dartmouth
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	Davies, T. H.	Down House, Stoke Bishop, Bristol
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	Hellyar, R.	18, Redland Grove, Bristol
	Herbert, J.	4, Southfield Road, Cotham, Bristol
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A	Hewer, T. F.	24, West Shrubbery, Redland, Bristol
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	Hodgson, C. J.	5, Cotham Terrace, Bristol
	Horder, Miss M. G.	Highweek, Brislington, Bristol
	Hoyle, W. E., D.Sc.	National Museum, Cardiff
	Ivens, H. P.	18, Alexandra Road, Clifton, Bristol
	Ivens, W. B.	49, Ravenswood Road, Bristol
	Jenkins, Mrs.	10, Napier Road, Redland, Bristol
	Jenkins, F. G.	6, Brandon Villas, Charlotte St., S., Bristol
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	Jervis, W. W., M.Sc., F.G.S. ...	The University, Bristol
	Jolly, H. F.	Glenavon, Clifton Down, Bristol
	Jones, Miss M. I.	23, Beaufort Road, Clifton
A	Knowlson, James F.	9, Downfield Road, Clifton
A	Knowlson, Mrs.	9, Downfield Road, Clifton
A	Lee, Miss E. M., M.Sc. ...	55, Logan Road, Bishopston
	Linton, Dr. Marion, M.B. ...	21, Oakfield Road, Clifton
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	Samson, F.	4, Woodfield Road, Redland, Bristol
	Sampson, Miss D.	30, St. John's Road, Clifton
*	Sandwith, Mrs.	26, Canynge Square, Clifton
A	Sandwith, N. Y.	Keble College, Oxford
*	Scott, W. G.	25, Duke Street, Cardiff
	Selman, Miss M. M.	9, Buckingham Place, Clifton
A	Shaw, Miss M. G.	4, Kenilworth Road, Redland, Bristol
	Shepherd, G. D.	Gresham Chambers, Kingsway, Cardiff
A	Sinnott, Jas.	15, Beaufort Road, Clifton
A	Smith, Miss A. M.	70, Pembroke Road, Clifton
A	Smith, Miss E. J.	70, Pembroke Road, Clifton
*	Smith, D. Munro, M.R.C.S. ...	479, Fishponds Road, Bristol
	Smith, W. A., M.A., M.B. ...	70, Pembroke Road, Clifton
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	Sully, H. T.	10, Durdham Park, Bristol
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*	Tutcher, J. W.	57, Berkeley Rd., Bishopston, Bristol
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A	West, Mrs. A.	5, Devonshire Road, Westbury Park
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Prof. Sydney Young, D.Sc., F.R.S., Trinity College, Dublin.

Reports of Council

To December 31*st*, 1920, *and* 1921.

THE year has been distinguished by more general interest and activity in carrying out the objects of the Society, in as much as the papers read have been on definite scientific subjects, with a larger attendance of members to hear them. The papers were contributed by members, showing that our Society includes those who are willing to take trouble for its success, whilst the Exhibition meeting in October brought out the capability of members to provide a number of examples of the varied subjects in which they had found interest for study during the year. In addition, five Informal Exhibitions on working evenings and four Excursions, have been held, these two undertakings being tried as new departures for this year.

The three Sections have done their utmost to excite interest amongst the general members, without, however, meeting with as much support from them as was desired, although affording excellent discussion and exhibits amongst those who were present.

The Excursions were purposely kept to the near neighbourhood, and the first three were fairly well attended and gave a pleasant reunion, whilst the fourth one, in September, was cancelled through insufficient members promising to be present.

Changes have taken place in the membership, leaving the Society with 143 members, of whom 32 still rank as Associate members. Although the total number is not so large as might be expected, the Society has added 28 new members, which is the highest on record of late years. We regret that we have lost by death two of our oldest members, Mr. Thompson Strickland, who joined in 1875 and was at one time hon. Treasurer, and Mr. Alfred E. Hudd, F.S.A., an original member and a life-long worker in Natural History, amongst other studies.

At the December meeting, the revised Laws were finally passed by the members in the form drafted by Council, and a copy of them will be distributed at an early date. There are no important alterations in them, except that newly-elected Associate members must be under 21 years of age.

The Society continues to hold its meetings in much the same manner as of late years, and a marked advance is apparent in the number of members who are carrying out definite scientific work. They regard it as having a close connection with the Society and seek to spread the results amongst their fellow members, to afford them generally new interests and encouragement.

At the same time the subjects of the Papers have been well distributed over various branches of Natural History, and the Exhibition in November far surpassed recent efforts and proved that in a quiet way a large number of members were taking an active interest in the life history of many objects.

The four Excursions have been much better attended this year, and have well served their purpose to bring about personal intimacy and exchange of views on the workings of Nature in the open air.

Early in the year, Council had the pleasure of accepting an invitation to an Exhibition meeting at the Museum of the recently formed Bristol Field Club, and was much gratified to see the good work being done.

The membership has changed, as withdrawals from the neighbourhood have led to resignations, but these have fortunately been made good by the election of fresh members, who are already showing their intention to participate in the activities of the Society. The total number of members is 144, of which 23 remain Associate Members under the old Law, and have not yet seen their way to change to full membership.

We have to record with much regret, in the closing days of the year, the death of Mr. Cedric Bucknall, a past Vice-President, and President of the Botanical Section. An account of his long connection with the Society and his work, will appear in our "Proceedings" at a later date.

In November, hearty congratulations were offered to the President, on his election to the office of Lord Mayor of Bristol for the coming year.

IDA M. ROPER, *Hon. Secretary.*

The HON. TREASURER in Account with the BRISTOL NATURALISTS' SOCIETY.

DR. GENERAL ACCOUNTS FOR THE YEARS 1920 AND 1921. CR

	1920. £	s.	d.	1921. £	s.	d.
To Members' Subscriptions—						
Ordinary	40	10	0	44	0	0
Associate	5	12	9	5	0	0
,, Entrance Fees	6	0	0	3	15	0
,, Subscriptions in advance	1	0	0	5	5	0
,, Arrears collected	19	15	0	14	0	0
,, Donations	3	0	0	—		
,, Sale of "Proceedings," etc.		12	0	1	12	10
,, Balance forward	67	1	10	99	10	6
,, Balance due to Hon. Treasurer ...	1	2	8	—		
,, Donations to Book-binding Fund ...	23	14	0		10	0
	£168	8	3	173	13	4

	1920. £	s.	d.	1921. £	s.	d.
By Subscriptions to Societies—						
Ray	1	1	0	1	1	0
Commons and Footpath ...		10	6		10	6
,, Cost of "Proceedings," 1918-1919	31	17	6	33	10	6
,, Printing	14	9	6	6	0	0
,, Fire Insurance		7	6		7	6
,, Rent of Library and Rooms ...	6	6	0	6	6	0
,, Postages, etc.	8	15	3	6	5	0
,, Gratuities	2	0	0	2	0	0
,, Cash in hand and Bank	100	16	0	106	17	1
,, Book-binding	2	5	0	10	15	9
	£168	8	3	173	13	4

Audited and found correct,

ERNEST H. COOK
CHARLES BARTLETT, A.C.A. } *Auditors.*

January, 1922.

Librarians' Report

For the Years 1920 *and* 1921.

THE use of the Library for reference or study at home has been continued in a more liberal manner, although members do not appear to consult as fully as they might the many Natural History publications which are at their disposal.

The appeal for funds for book-binding has been moderately successful, and the amount subscribed has been expended to bind the many volumes of "Proceedings" received by exchange from British Societies to bring their series up to date.

After some years' delay in publication the American Universities and Societies have sent a large number of printed papers on Natural History, referring for the most part to work on their own Continent.

The Ray Society, to which we subscribe, has sent its annual volume, the latest being *British Orthoptera,* by Lucas.

The Library has also received by gift :

Royal Society Philosophical Transactions, 1920, from Dr. Sidney Young.

Living Races of Mankind, 2 vols. Kirby and Spence, *Entomology,* 7th edition, 1856. Botanical Paintings by Miss E. F. Philpott, from Dr. A. B. Prowse.

University of Bristol Speleological Society, Vol. I., No. 1, from Prof. O. V. Darbishire.

Several Volumes of "Papers read at Meetings of Architectural Societies in the Midland Counties," 1881-1895, from Mrs. Sandwith.

Geological Magazine to date, from the Geological Section.

The Entomologist and *Entomological Monthly Magazine,* 1918, from the Entomological Section.

Economic Guides on the House Fly, Furniture Beetles, etc., from the Trustees of the British Museum.

And thanks are given to the donors for them.

A demand for our "Proceedings" continues, especially for those containing Geological research, and it would be an advantage if original papers were available for publication on Entomological subjects.

The Library is proving its value inasmuch as an increased number of volumes have been in circulation, of which those connected with Entomology are the most in request. The marked activity of the Entomological Section in carrying out systematic study, especially amongst members who have recently joined the Society, accounts for this demand, and points to the desirability of gifts being made of modern books on Entomology to assist the student.

A good example in this direction was set by the gift of a cabinet of European Lepidoptera from the collection of the late Mr. A. E. Hudd, F.E.S.

The Library has also received by gift :—

"Newman's British Ferns," 1854, from Mr. H. S. Thompson, F.L.S.

"British Science Guild Reports," Nos. 1–14, from Mr. G. C. Griffiths.

"Liverpool Botanical Society's 'Proceedings,'" 1916-18, from Dr. W. A. Lee, M.A.

"Palæontographical Society," Vol. 72, 1918, and "Geological Magazine," 1921, from the Geological Section.

And thanks are given to the donors for them.

The Ray Society, to which we subscribe, has sent its annual volume, *British Freshwater Rhizopoda and Heliozoa,* by Wailes, Vol. 5, and the Corresponding Societies have sent numerous current publications.

The binding of volumes of "Proceedings" received from British Societies has been further carried out, but those of Foreign Societies remain loose, on account of the want of suitable shelf space and of funds to meet the cost of binding.

ARTHUR B. PROWSE, LIEUT.-COL., R.A.M.C.,
Hon. Librarian.
IDA M. ROPER, F.L.S., *Hon. Sub-Librarian.*

Exchange List.

Ashmolean Natural History Society of Oxfordshire
Barrow Naturalists' Field Club
Belfast Naturalists' Field Club
Birmingham Natural History and Philosophical Society
Bristol Museum and Art Gallery
———, University of, Speleological Society
British Association
——— Museum (Natural History), S.W.
Cardiff Naturalists' Society
Chester Natural Science Society
Cornwall, Royal Geological Society of
————, Royal Institution of
————, Royal Polytechnic Society
Cotteswold Naturalists' Field Club
Croydon Natural History and Scientific Society
Ealing Scientific and Microscopical Society
Edinburgh Geological Society
——————— Royal Botanic Society
Essex Field Club
Geological Society of London
————— Survey and Museum, London
Geologists' Association
Glasgow, Geological Society of
————, Natural History Society of
———— Philosophical Society
Hertfordshire Natural History Society and Field Club
Liverpool Geological Society
———— Literary and Philosophical Society
———— Science Students' Association
Manchester Literary and Philosophical Society
————— Microscopical Society
————— Museum Library
Marlborough College Natural History Society
Norfolk and Norwich Naturalists' Society
North Staffordshire Field Club
Nottingham Naturalists' Society
Plymouth, Marine Biological Association of the United Kingdom
————— Institution and Devon and Cornwall Natural History Society
Quekett Microscopical Club
Royal Irish Academy
Royal Microscopical Society
Rugby School Natural History Society
Torquay Natural History Society
Yorkshire Geological and Polytechnic Society
———— Naturalists' Union
———— Philosophical Society

OUR "PROCEEDINGS" ARE SENT AS A FREE GIFT TO :—

British Museum Library
Cambridge University Library
Dublin, Trinity College Library
Edinburgh, Advocates' Library
Oxford, Bodleian Library
Patent Office Library, London

AUSTRALIA.

Australasian Association for the Advancement of Science
New South Wales, Geological Survey of
————————, Royal Society of
Queensland Museum, Brisbane
Victoria, Royal Society of

CANADA.

Canadian Institute, Toronto
Hamilton Scientific Association
Nova Scotian Institute of Natural Science (Halifax)

INDIA.

Agriculture, Imperial Department of
Geological Survey of India, Calcutta

FRANCE.

Lyons, Société Linnéenne de
Rennes, University of

NORWAY.

Det Kongelige Norah Universitet Christiana

SWITZERLAND.

Lausanne, Société Vaudois des Science Naturelles
Zurich, Naturforschende Gesellschaft

UNITED STATES.

American Museum of Natural History, New York
Augustana College, Rock Island, Illinois
Boston, Mass., Natural History Society
Brooklyn Institute of Arts and Sciences, Coldspring Harbour
California, University of, Berkeley
Californian Academy of Sciences, San Francisco
Cincinnati Natural History Society
———, Lloyd Library
Colorado College, Colorado Springs
———, University of, Boulder
Denison Scientific Association, Ohio
Elisha Mitchell Scientific Society, Chapel Hill, N.C.
Essex Institute, Salem, Mass.
Illinois, University of, Urbana
Indiana Academy of Science
Michigan Academy of Science
Missouri Botanical Gardens
——— Academy of Science, St. Louis
New Mexico, University of, Albuquerque
Ohio, State University, Columbus
Oklahoma State University
Philadephia Academy of Natural Sciences
———, Wagner Free Institute of Science
Smithsonian Institution, Washington
Tufts' College, Mass.
United States Geological Survey, Washington
——— National Museum, Washington
Yale University, Connecticut

ARGENTINE REPUBLIC.

Buenos Aires, Muses National de Historia Natural

URUGUAY.

Montevideo, Museo Nacional de

MEXICO.

Mexico, Sociedad Cientifica

Geological Section, 1920 and 1921.

THE year closed with the satisfactory record of 46 members, being an excess of 7 over the previous year. The real increase, however, is greater, as every member is now a working one and has paid the subscription to date. A new register has been prepared, and it is to be hoped the Section has entered on a new era of usefulness.

Seven meetings were held during the year, with an attendance of 32.

Jan. 22.—" The volcanic Geology of the Naples District." * By the President, Prof. S. H. Reynolds, F.G.S.

Feb. 19.—Exhibition meeting.

Mar. 18—" Palestine." * F. S. Wallis, F.G.S.

May 20.—" Caves." * H. C. Grigg.

Oct. 21.—Exhibition night.

Nov. 18.—" Organic Rock Builders." * H. W. Turner, B.A.

Dec. 9.—" Lithology of Avon Section." * Prof. S. H. Reynolds.

At the Annual General Meeting on Jan. 22, Mr. D. E. I. Innes, M.A., was elected Hon. Secretary and Treasurer, in succession to Mr. B. A. Baker, who had acted for the Section for nearly 20 years. In June Mr. Innes resigned on leaving Bristol, and Mr. F. S. Wallis, B.Sc., F.G.S., undertook the duties.

The subscription to the Palæontographical Society has been paid, and the Section is now up to date on both the publications, which are presented to the Society.

The Section has admitted 14 new members, but on account of the formation of a University Geological Club the resignations have reached 27, and the membership now stands at 33.

Seven meetings were held during the year, with an attendance of 27.

Jan. 27.—" The late W. W. Stoddart and his contributions to local Geology." J. W. Tutcher.

Feb. 17.—" Building Stones." * Miss E. Long.

Mar. 10.—" Soils and Substrata." * Miss R. Griffin.

Apr. 28.—" Submerged Forests and raised Beaches." * Miss A. Riddiford.

Oct. 20.—" Charles Lapworth." Prof. S. H. Reynolds.

Nov. 17.—" Geology of Upton Cheney, North Stoke and Kelston Hill." Mr. T. Fry.

Dec. 15.—" The Carboniferous Limestone of Bristol district, with special reference to Broadfield Down, Som." Mr. F. S. Wallis.

* *Illustrated by lantern slides.*

Four excursions were carried out in the Summer, with an average attendance of 6, to Shirehampton and Avon Gorge ; to Yate ; to Portishead ; and to Dundry.

Early in the year Mr. J. W. Tutcher presented a book for the members to make records of any local matters of geological interest, and he started with the entry of a few local exposures.

As the University students have formed a Club in connection with the Guild of Undergraduates the future of the Section, both as regards work and finance, will need careful consideration.

F. S. WALLIS, F.G.S.,
Hon. Secretary and Treasurer.

Entomological Section,

1920 and 1921.

THESE years have shown a greatly increased interest in Entomology, and the Section ends the period with a membership of thirty.

Eleven indoor meetings have been held at the house of the President, Mr. G. C. Griffiths, to whom the thanks of the members are due. One paper, communicated by Mr. H. J. Charbonnier, has been read on "Mimicry and Protective Resemblance in Insects," and Dr. C. King Rudge made some interesting observations upon the beetle *Coccinella distincta* and its association with ants, illustrated by specimens in all stages.

A large number of notes have been made and exhibits produced of all orders of insects, the following captures being the most important :—

Mr. A. E. Hudd. Three specimens of *Limnobia decemmaculata*, taken in Leigh Woods, May 20 and June 11, 1918, and Sept. 27, 1919. This species was not represented in the British Museum and is not in Mr. Verrall's list of British Diptera.

Mr. C. Bartlett. The following species of Coleoptera, new to the British List, taken from drifting pine logs at Mortehoe, N. Devon, in 1918, and since identified as *Hypophlœus fraxini* Kugel or *H. pini* Panz. ; *Tomicus erosus* Woll ; *Hylurgus ligniperda* F.; *Platysoma oblongum* F.

Also *Leucania unipuncta* Hw, taken at sugar near Padstow, Sept. 17, 1920.

An exhibition meeting, arranged by the Section and open to all members of the Society, was held in the Museum on May 18, 1920, and well attended. The Vaughan collection of lepidoptera and members' exhibits were inspected. The Museum is to be congratulated upon the possession of a very fine series of the rare *Drurya antimachus* recently presented.

Six excursions have been made to Leigh, Nailsea, Backwell, Portishead, Ashcott, and Winscombe ; the two last being held jointly with the Entomological Section of the Somerset Archæological and Natural History Society.

The Section has to record with regret the loss in 1920 of one of its original members, Mr. Alfred E. Hudd, F.E.S. From the date of the formation of the Section, May 12, 1864, the late member maintained his interest and valuable work in local entomology.

The Council of the Society has accepted the following as a Bye-law of the Section : "The President and Secretary of the Entomological Section of the Somerset Archæological and Natural History Society may be elected *ex-officio* members of the Section."

Prebendary Wickham, of East Brent, President, and Mr Henry Slater, of Cannington, Hon. Secretary, have accordingly been elected hon. members, and a good result is expected in future through the co-operation of the two sections.

CHARLES BARTLETT,

Hon. Sec.

Account of the Annual and General Meetings.

THE 57TH ANNUAL MEETING.

January 15th, 1920.

The Council and Officers with minor alterations were re-elected, Dr. E. H. Cook, Sc.D., being President for the second year. He delivered his first Presidential Address entitled "Natural Sources of Energy" (printed in full on page 170).

THE 479TH GENERAL MEETING.

February 5th, 1920.

"Plantation Rubber in Malaya," by Mr. Percy F. Coe.

The cultivation of Rubber dates in Malaya only from about 1898. At that time the seeds of the Para Rubber tree, *Hevea brazilensis*, was introduced from the basin of the River Amazon in Brazil, this species of Euphorbiaceæ being specially chosen, because it was a native of upland forests in deep soil in wet Tropical regions, which were just the conditions it would meet in the Malaya.

On the fifth year the tree is tapped for rubber by marking off the lower three feet of each by four vertical straight furrows. Down these the milky juice trickles, fed by a fine line, which is cut daily in a slanting direction through the smooth bark of the latex tissue, great care being taken not to cut into the growing layer beneath. The Planter is kept fully occupied in the enervating and wet climate to check damage to trees from animals, insects and fungi, and to prepare the finished sheets of rubber for market.

Coloured lantern slides illustrated the details of daily life on the lecturer's own estates.

Exhibit by Miss Ida M. Roper, F.L.S., of fine examples of *Peziza coccinea,* parasitic on hazel.

THE 480TH GENERAL MEETING.

March 4th, 1920.

"The Hymenopterous Parasites called 'Fairy Flies,'" by Dr. B. N. Blood, M.D.

These flies are so minute that little study has been given to the sub-family Mymaridae, although many species can be obtained by sweeping over long grass. The iridescence of their wings, and the marvelous forms of the organs make the insects objects of great beauty. Slides to illustrate the life stages were shown. Attention was called by Dr. C. K. Budge to the similarity of the beetles *Coccinella distincta* and *Clythra 4-punctata,* both of which are found in close association with ants' nests.

THE 481ST GENERAL MEETING.

April 8th, 1920.

"Some Common Birds of the Neighbourhood and their Nests," by Dr. D. Munro Smith.

The habits and distinctive notes of warblers, tits and other well-known birds were described, with useful hints on the places in which their different kinds of nests may be looked for. These were illustrated by pictures taken locally by the lecturer, and supplemented by coloured drawings made by Mr. H. J. Charbonnier, which are in frequent use in the Elementary Schools of the City.

Exhibit by Mr. N. Y. Sandwith of the long-stalked Morel, *Mitrophora semilibera.*

THE 482ND GENERAL MEETING.

May 6th, 1920.

"The Life History of a Diatom," by Mr. Cedric Bucknall, Mus. Bac. (Printed in full on page 126).

Exhibits by Mrs. Sandwith of the micro-fungus *Peziza trechispora;* by Mr. N. Y. Sandwith of *Alchemilla alpina,* from the Lake District.

FIELD EXCURSIONS.

During the Summer of 1920 three excursions were held, and were fairly well attended.

June 5th, Yate Common. July 3rd, Leigh Court Woods. July 24th, Portishead Big Wood. The President, Dr. E. H. Cook, and his daughter, Mrs. Langford, entertained the members to tea.

An excursion to Oldbury Court Woods, Frenchay, on September 18th, was cancelled through lack of support.

THE 483RD GENERAL MEETING.

October 7th, 1920.

Exhibits of Natural History by the Members.

Dr. A. W. Smith exhibited two 17th century Herbals.

Dr. C. K. Rudge, the anatomy of the throat organs of various large Waterfowl.

Mr. G. C. Griffiths, F.E.S., Mr. H. T. Sully, and Mr. H. Womersley, Lepidoptera and local Diptera. Mr. J. W. Tutcher and Mr. T. B. Fry, local Echinoderms and a large Crinoid from the Avon Gorge. Mr. A. T. Davis, F.R.M.S., leaves of *Paulownia*

imperialis bearing secondary leaflets. Miss Ida M. Roper, F.L.S., a very tall specimen of *Helleborine latifolia* with a photograph of it *in situ*. Mr. N. Y. Sandwith, the colonists *Fumaria Martini*, a first record for Somerset, and *Galeopsis dubia* from the peat moors. Mr. H. J. Gibbons, the Ergot of Rye, *Claviceps purpurea*.

Other members exhibited flowering sports, Alpine flowers, cryptogams, etc.

THE 484TH GENERAL MEETING.

November 3rd, 1920.

"The Geology of Mesopotamia," by Capt. W. W. Jervis, F.R.G.S., F.G.S.

The geology of the country after experience of it during the late War could be described as simple, as it is formed of sand and alluvial soil deposited by the two great Rivers. The soil, however, was made the best of during warfare for trenches, defence houses, and wagon roads in spite of the plagues of disease and flies produced from it.

Exhibits by the President, Dr. E. H. Cook, of a Death's Head Moth, *Acherontia atropos*, caught in his house; and by Mr. G. C. Griffiths, F.E.S., of a series of the same moth showing variations in the markings.

THE 485TH GENERAL MEETING.

December 2nd, 1920.

"Drifting Plant Life of Lake and Ocean," by Prof. O. V. Darbishire, F.L.S.

Enquiry about plankton of the sea began about 1872, and has been assiduously followed up by Scientists ever since, because this food for fish is of great economic importance. Several types of diatoms were shown by microscope and lantern, whilst the appliances for collecting were on view.

Exhibit by Lt.-Col. A. B. Prowse of the leaves of the Japanese Medlar, *Eriobotrya japonica*, remarkable for the brilliant autumnal colouring.

THE 58TH ANNUAL MEETING.

January 20th, 1921.

The election of Officers was confirmed, with Mr. T. Morgans and Mr. J. Rafter, M.A., becoming Vice-Presidents, and Mr. H. J. Gibbons entering again into Council by exchange. Dr. E. H.

Cook, Sc.D., was elected President for the third time, and delivered his second presidential address entitled "Natural Sources of Energy and Food Supply" (printed in full on page 182).

THE 486TH GENERAL MEETING.

February 3rd, 1921.

"Hæmoglobin and Chlorophyll," by Prof. G. A. Buckmaster, M.D., F.R.S.

It is difficult to explain the state in which hæmoglobin exists in the blood ; it may be in colloidal solution, but it is not in ordinary solution. It contains 99 per cent of the total iron in the human body, which needs constant renewal by the eating of green vegetables. A further important function of hæmoglobin is to remove waste gases from the blood and replace them by oxygen.

Chlorophyll of plants is similar in chemical composition, but holds magnesium instead of irons. Its chief functions are to set free oxygen from carbonic dioxide, and to absorb sunlight and pass it into the protoplasm of the cells to be stored up as vital energy.

Some capital experiments in connection with light and the spectrum were carried out.

THE 487TH GENERAL MEETING.

March 3rd, 1921.

"Insects and Disease," by Mr. H. Womersley.

The germs of disease may be carried directly by the feet, proboscis and other parts of the House-fly, the Louse and Rat-flea or transmitted indirectly by the Mosquito and Tetze fly. The House-fly and its ally, the Blow-fly, bring to our food deadly germs from decaying animal and vegetable matter, and during the war the active campaign carried on against the flies by cleanliness throughout the camps was of inestimable value to our troops. Similarly the need was explained how to destroy utterly the haunts of tropical insects to banish malaria and sleeping sickness. A fine series of lantern slides illustrated the life history of the insects.

Exhibits by Mr. G. C. Griffiths, F.E.S., of the Moth, *Scoparia ambigualis*, from the Vaughan collection, Bristol Museum, labelled c. 1850, by a name no longer in use ; and by Prof. O. V. Darbishire, F.L.S., of the bacterium *Lamprocyetis*, which deposits sulphur from the sulphuretted hydrogen generated by decaying vegetation in ponds.

THE 488TH GENERAL MEETING.

April 7th, 1921.

"Human Prehistoric Development in Relation to Contemporary Environment," by L. S. Palmer, M.Sc., Ph.D.

(Printed in full on page 192).

Exhibits by Miss Ida M. Roper, F.L.S., of a bronze medal of 1830 awarded by the Society of Apothecaries to an unknown student of Botany; by Prof. O. V. Darbishire, F.L.S., of a spider's web formed in a darkened tumbler; by Mr. Coldstream Tuckett of a photograph of a local nest and egg of the Great Crested Grebe

THE 489TH GENERAL MEETING.

May 5th, 1921.

"Leather Tanning," by Mr. T. H. Davis.

(Read by Mr. S. Hirst).

The raw hides or skins are first treated in lime liquors, which enables the hair to be removed, and prepares the pelts for subsequent tannage. Tanning agents are divided chiefly into two classes, vegetable and mineral tannages. Sole leather is mostly vegetable tanned, and boot upper leather is chiefly chrome tanned. The many processes involved in the production of vegetable tanned leather and in the two chrome tannages (the one-bath process for the heavier chrome leathers, and the two-bath process for the finer chrome leathers) were described. The methods of drying and finishing the different classes of leather were also explained. In the production of leather great care has to be taken at every stage to ensure the correct result, and many of the processes have to be very carefully controlled. Instances were given of the many dangers it was necessary to avoid, in order to obtain a finished article of first-class quality. Skins in various stages of the tanning process were shown and explained.

FIELD EXCURSIONS.

During the summer of 1921 four excursions were held, and were well attended.

June 4th, Failand Hill. Colonel and Mrs. R. Brittain entertained the members at tea. July 6th, Leigh Court Woods. August 13th, Brislington to Keynsham. Mr. P. F. Gibbons, J.P., and his wife entertained the members at tea. September 3rd, Kingsweston district.

THE 490TH GENERAL MEETING.

October 6th, 1921.

"The Birds of the Downs," by Mr. H. S. Hall, M.A.

A fascinating account was given of many birds who build their nests on the Downs. The tits and finches are well represented, and amongst the warblers the blackcap is the commonest. Some great rarities are occasionally seen, and the lecturer told of the many hours spent in observing the habits of the nightingale, of whose nests he had marked down no less than fifty-three on the wooded slopes bounding the Downs. The nests being made of dead oak leaves are extremely difficult to find, and he had devoted much time and patience over the yearly search for them

THE 491ST GENERAL MEETING.

November 3rd, 1921.

EXHIBITION NIGHT.

Objects of interest in Natural History were displayed by twenty-nine exhibitors. Short talks were given about some of them by Dr. C. K. Rudge, who explained the structure of sea urchins and starfish ; Mr. H. Womersley spoke on parasitic diptera and an observation box of living yellow ants ; Mr. C. Tuckett on local birds and their nests ; Mr. J. W. Tutcher on fossil plants from the Radstock coal-measures ; Mr. J. W. White, F.L.S., on rare plants of the district ; and Mr. H. S. Thompson, F.L.S., on the ecology of the Burnham sand dumes.

Coffee was served during the meeting.

THE 492ND GENERAL MEETING.

December 1st, 1921.

"Chemical Observations on some English Plant Galls," by Dr. M. Nierenstein, Ph.D.

About 1680 Malpighi investigated Plant Galls and believed them due to irritant fluid from the insects, and two centuries later Reamur and Darwin came to the conclusion mechanical irritation of the tissues by the grub led to the formation. It was only in 1914 that Magnus proved that the bite breaks the tissues and sets up irritation, whilst it is the production by the egg of enzymes or ferments that dissolve the fibre and bring about the visible gall on the plant.

It is a tannic acid compound that effects the change, and is of two kinds, either the normal tannin of plants or the special

one found only in galls, which give blue and green colourations respectively with iron salts.

After 20 years of study on the chemical conditions in galls Dr. Nierenstein has established the following facts:—The colouring matter of galls is not due to that of the plants, and there is no connection between them.

The presence of tannin does not serve to protect the plant, because no nitrogenous products are found; nor does tannin from the plant provide nourishment for the insect, as is proved by the absence of sugar in the gall.

On the other hand the insect may produce tannins, seeing that the mould *Penicillium glaucum* is capable of converting galloylamino acids into ellagic acid, which is an oxidation product of gallotannin.

PRESIDENTIAL ADDRESS, 1920.

"Natural Sources of Energy."

By E. H. Cook, D.Sc.

"I had a dream which was not all a dream,
The bright sun was extinguished and the stars
Did wander darkling in the eternal space,
Rayless and Pathless, and the icy earth
Swung blind and blackening in the moonless air."

WITH these words the poet commences a description of the horrors that he imagines would follow the sudden cessation of the outpouring of energy from our central luminary. All life and movement cease, and Darkness and Death become the Universe. I quote the passage in view of a recent notorious prophecy, and to emphasise our dependance upon the Sun for every form of life and movement upon Earth. Throughout countless æons of time, heat and light have been emitted without, so far as can be ascertained during the world's recorded history, any weakening taking place.

Whence the original source of energy was derived and how it is maintained, are speculations which need not be gone into, but at some far distant period the terrestrial condition became such that it was possible for living things to exist.

There is a fascination in the study of the beginnings of life upon this planet, as well as in the discovery of the records of the rocks which enable us to trace the gradual development which has taken place from the first lowly constituted organism up to the highly complex and argument-loving being known as *homo sapiens.* Every one of the millions of living things which at one time or other has lived upon this earth has drawn upon the sun's store of energy for the necessities of its existence. The prodigality of the supply of the enormous floods of heat, light and other forms of radiation can only be even partially realized when it is remembered that the only portion of the emanations that fall upon the earth are those intercepted by an approximately spherical body, 8,000 miles in diameter, forming part of an approximately spherical shell 185,000,000 miles in diameter. This fraction can be calculated, and is found to be equal to one two-thousand-three-hundred-millionth of the whole total given out. Various calculations have been made to help in giving some idea of the immensity of the amount of heat and light given out by the sun. but the numbers are so prodigious that they are beyond the power of the mind to grasp. Thus when it is said that its heat "would boil 700,000 millions of cubic miles of ice-cold water per hour" the statement

conveys no meaning, although I calculate this is more than 1,000 times the whole of the water on the earth—liquid, solid and gaseous, put together. But it is certain that some of these rays falling upon the earth in bygone times produced conditions which resulted in the growth of the vegetable matter subsequently transformed into our Coal Seams.

The possession of the vast quantities of Coal and its early exploration has contributed to the leading position which this country has long enjoyed amongst the manufacturing districts of the world. We have been so accustomed to Coal Fires from our childhood that it is difficult to believe that at one time they were quite unknown. Nevertheless, such was the case. It is quite certain, for instance, that King Alfred allowed the cakes to burn over a wood fire, and it is not until 1239 that we have any clear proof that coals were raised for fuel. In that year Henry III. is said to have granted a charter to the townsmen of Newcastle to dig for coal. In 1306, however, King Edward I. "prohibited the burning of sea-coale in London." Nevertheless, in twenty years' time, in consequence of a scarcity of wood, "sea-coale" was again in London, and even in the Royal Palace, but the old King was dead.

But our industrial activity only began at about the middle of the eighteenth century, less than 200 years ago. So easy was the conversion of the potential energy of the coal into actual mechanical power, that we soon became the workshop of the world, and in consequence of this we have been able to increase our population from about 10½ millions in 1750 to one of about 40 millions in 1914.

At present we are raising about 250,000,000 tons a year, and it is calculated that our British Coal Supply at that rate will be exhausted in about 500 years.

There is no necessity for individual alarm therefore, but it is certain that when that time arrives and long before, the conditions under which human existence will be carried on will be so profoundly altered as to be incapable of realisation by us.

Coal, then, may be said to have made England, and how dependant upon it we are was shown by the late lamentable troubles which caused such a dislocation in the industrial world. But have we not allowed ourselves to be too tightly tied to the one source of supply? Has not the ease with which it can be used caused us to neglect other sources which Nature has provided, and which await utilisation?

The object I have in view in writing this address is to endeavour to call attention to these questions and to suggest a reply.

In approaching the subject, it is well to bear in mind two fundamental facts which, notwithstanding all the wonderful developments of modern science, still remain as our sheet anchors. Briefly they may be stated as follows :—(1) Matter can neither be created nor destroyed ; and (2) Energy can neither be created nor destroyed.

It is with the second of these that we have to deal at present. It has already been shown that the original source of all terrestrial energy is the sun, and if the second law holds good it must follow that an equivalence must exist between various modes of manifestation of energy. Thus, for example, mechanical energy should be capable of expression in terms of heat, electricity, etc., chemical energy in terms of heat, electricity, etc., and so on. Science has long proved to us that this is the case, and has measured for us the numerical equivalents. Thus if the work required to raise a weight of 1 lb. through a vertical height of 1 ft. be taken as the unit, then the heat used up in raising the temperature of 1 lb. of water 1 degree Fahrenheit, if all converted into this mechanical form would raise a weight of 772 lbs. through one foot ; or in other words produce 772 units of work. If by the employment of any agent 33,000 units of work are done in one minute, the agent is said to be of one Horse Power. Of course, these units are arbitrary and selected simply for convenience.

The heat produced by the burning of substances in the air is caused by the clash of the atoms of the oxygen with those (generally carbon and hydrogen) of the substance. By the burning of 1 lb. of a sample of British Coal of average composition, enough heat is generated to raise the temperature of about 12,000 lbs. of water 1 degree Fahrenheit ; consequently 12,000 multiplied by 772, or roughly $9\frac{1}{4}$ millions of units of work would be done if all the energy were converted into mechanical. If we suppose it took one hour for this pound of coal to burn, and that no heat was lost either by the products of combustion, by the heating of the containing vessel, or in many other ways, an engine of 4 horse-power could be worked for one hour. But in practice a vast amount of heat is lost, and even with the most perfect appliances, the percentage of the theoretical energy of the coal that can be utilised only amounts to about 15 per cent.

At the present time about 36,000,000 tons of our coal supply is used for domestic fires, and 20,000,000 for carbonizing in gas works ; 164,000,000 are used for the production of steam (including about 10,000,000 in Electrical undertakings), and 30,000,000 are exported (this figure I have taken as between Sir Auckland Geddes' estimate and that of the Miners' representatives). Undoubtedly in the future vast improvements will be introduced in the utilization of the latent energy in coal, and a nearer approach to the

theoretical yield be obtained, but it is certainly not wise to rely upon one source of supply.

I shall possibly have few objectors when I venture to assert that the provision of cheap motive power is one of the most pressing needs of the time. All our industries require it, and increased productiveness, which is so absolutely vital to our existence as a great nation, will result.

Nor have we far to seek, for it is only necessary to look around to find energy exhibited in the unceasing movement of masses of air and of water.

The utilisation of some of the motive power of winds and of running water is comparatively easy, and calls for accomplishment. The abundance and low price of coal and the development of the steam engine has caused us to neglect these, and we are probably more backward than most countries in this respect. There are indications scattered up and down the country that this was not always the case. Neglected windmills and water wheels are common, and these probably served the requirement of a less strenuous time. But a very short experience showed that frequently there were periods of dead calm when the wind would cease to blow, and that long droughts would make the rivers very low and there would not be enough water to drive the mill. And of course it seemed to the proprietor that these periods always occurred when the necessity for continuous working was greatest. We cannot wonder that a more certain and constant source of supply was adopted or that coal and the steam engine displaced wind and water.

Undoubtedly the intermittent and irregular nature of the supply of these natural sources of energy—wind and water—has been the principal cause of their neglect. The great desideratum is the provision of efficient storage arrangements, so that the excess in times of plenty may be used in periods of poverty. The conversion of mechanical power into electricity and the development of the dynamo, which were among the wonderful scientific discoveries of the last century, helped matters considerably, and when the storage battery was introduced it was thought that the problem had been solved. It is true that some installations have been set up since that time—about 1880—but comparatively few and insignificant.

The great increase in the cost of coal that has taken place within the last few years ought to turn attention once again to the subject The financial prospects of commercial success are probably much better. It is remarkable that in regard to the storage battery invented by Faure and introduced to the electrical world so

enthusiastically by Sir William Thomson in 1881, practically no improvement of importance has taken place during the years that have elapsed. It is reasonable to expect that with more attention other and better methods may result.

In considering the subject in detail, we will first consider moving air.

Of course, the magnitude of the supply of energy from wind pressure is not to be compared to that from running water. But the neglect of small things is a national failing. It was this failing which caused us in their early stages to lose the aniline dye industry, as well as that of the manufacture of fine chemicals and also the making of toys. They were not big enough for serious consideration, so our manufacturers considered ; but when it was seen to what an extent these industries and others developed under careful nursing, a very different view was taken, and we have since spent millions to win back what a few thousands would have preserved. Yet there are industries and circumstances where the motive power might economically be obtained from windmills. Hitherto no attempt has been made to utilize air pressure in conjunction with water power, but I venture to suggest such a combination as easy of accomplishment, and that it offers a very promising field for exploration.

The unequal heating of the earth's surface both land and water by the sun's rays is the cause of the production of almost all our winds ; these winds scatter the aqueous vapour formed by the heating of the water into all parts of the atmosphere. So long as it retains sufficient heat it remains as transparent vapour, but when from sundry causes its temperature falls, condensation takes place and some of the water falls as rain. Once on the earth the water does three things ; first, some of it immediately evaporates into vapour ; secondly, some sinks into the ground to form our underground supplies ; and thirdly, some runs over the surface to lower and lower levels and ultimately reaches the sea as streams and rivers.

If we know the average rainfall of the country, and the amount of drop in height from the water-shed to the sea, we can calculate the approximate amount of energy, after making due allowance for losses contained in the moving water. Such a calculation was made many years ago for Ireland by my friend, the late Sir Robert Kane, F.R.S. He arrived at the conclusion that that country possessed " a water power capable of acting without interruption from the beginning to the end of the year amounting to 1,248,849 horse-power." An insignificant amount of this power has at any time been utilized, notwithstanding the absence of any coal seams in the country.

Somewhat similar calculations may have been made for England and Scotland, but I do not know of any.

It would be a very laborious but perfectly straightforward enquiry to measure approximately the amount of water carried down by our rivers to the sea. It has been computed that out of the total rainfall of a district from one-fourth to one-third finds its way to the sea. The enormous amount of water carried down can be made evident by a few examples. Thus the Thames rises in the Cotswolds 376 feet above the sea level, runs for 215 miles and drains about 6,000 square miles of country. From a long series of experiments extending over twenty years (1883-1902) Mr. Baldwin-Wiseman finds that the mean annual rainfall for the whole Thames basin is 26.12 inches. Out of this from measurements made at Teddington Weir there runs to sea every day 1,110 millions of gallons, or 29.6 per cent. of the whole rainfall. This calculates into 3,400 tons per minute, and if we suppose a drop of 10 feet to take place in the minute we get a horse power of about 2,300.

The Severn carries down to the sea a much larger quantity of water than the Thames, because it drains a district where the average rainfall is greater. Thus, even at Shrewsbury, so far up the river the average daily flow of the river during 1900 whilst experiments were in progress, approximated to 900 millions of gallons per 24 hours. That means approximately 2,800 tons per minute and a Horse Power of 1900, going on continuously.

I regret that I have not been able to obtain any statistics of the average daily flow of our river Avon but of course the figures would be much smaller, but nevertheless considerable.

But as we all know, the passage of this water to the sea is very irregular. From actual experiments already quoted at Shrewsbury, it was found that the height of the river varied from 1 foot 5 inches on a day in September, to 10 feet 8 inches on a day in December, whilst the actual flow varied from 112,000,000 gallons to 1055,000,000 in 24 hours. In the Avon it is common to have 10 foot of fresh water in times of flood whilst as much as 17 foot have been noted.

But for the easy utilization of the energy of running water, it is desirable that its descent should be rapid. Hence the importance of cataracts and waterfalls and a mountainous country. In this respect we are not so favoured by nature as many other districts; Norway and Switzerland, for example will immediately be remembered by those who have travelled in them as having abundant water powers, a fair proportion of which is being utilized.

Whenever waterfalls are mentioned, the mind naturally turns to the two great examples—those on the Zambesi and those on the Niagara. Both are of enormous proportions.

The Victoria Falls are the larger but less known. The Zambesi is a magnificent river over 1,000 miles in length and remarkable for its internal communications, draining as it does a very large tract of Central Africa. At the Falls the width is 2,000 yards as against 1,405 at Niagara and the drop is 420 feet as against 162 at the American Fall. The mean volume of water passing over the Falls at the Zambesi is less than that at Niagara, being 80 million gallons per minute as against 83½ million gallons. Calculating from these figures we get a mean theoretical horse power at the Zambesi of about 10,000,000 and at Niagara of about 4,000,000. It will be noted that this gives a much smaller figure than that given by Professor Unwin later on.

From a spectacular point of view Niagara is the more open, and there are many vantage spots from which the magnificent panorama can be viewed. The waters at the Zambesi tumble into a chasm three-quarters-of-a-mile long and about 150 yards wide, which opens out into a wider gorge extending for 45 miles. The roar of the falling waters can be heard many miles away, and the clouds of vapour (or smoke, as the natives call it) can be seen at a great distance. Livingstone, who was their discoverer, thought that he saw the smoke from burning grass when he first beheld the vapour seven or eight miles away. The sense of power and irresistible energy is awe-inspiring, and the setting of the picture in the midst of luxurious tropical vegetation adds greatly to the beauty of the scene.

The general features and many of the details of the Falls on the Niagara are well known. The idea of utilizing some of the enormous power has long been held, and so long ago as 1725 a saw mill erected a short distance below the Falls was driven by water drawn from them. But in 1889 a very powerful corporation of scientists, engineers and financiers called the Cataract Construction Company was formed with the definite purpose of developing as a business proposition some of the power of the Falls without unduly interfering with their natural beauty. The works were begun in March, 1890, and in April, 1895, the first 5,000 horse-power turbine out of an installation of 50,000 was started. Since that time enormous developments have taken place both on the American and the Canadian side, and the project is a commercial success. In fact, it was calculated so long ago as 1896 that with coal at 12s. a ton and a 24-hour load it was cheaper for a manufacturer to buy his power from the supply given by the Falls than from raising it by steam ; if he resided within a distance of 330 miles. But lest it may be imagined that the large power already withdrawn may impair the natural beauty, it may be mentioned that the late Professor W. C. Unwin, who was the Secretary of the International Commission who investigated and advised upon the best methods

of utilizing the energy of the Falls, calculated that on a low estimate these Falls represent 7,000,000 of horse power, and that several hundreds of thousands of horse power may be made use of practically without appreciable diminution of the natural beauty. With perfect truth, Sir W. Thomson (afterwards better known as Lord Kelvin) once said that the power wasted at the Niagara Falls would, if transmitted to Great Britain, drive all the engines in the country. He forgot to add that in all probability there would not be sufficient copper in the world to convey the electricity across the Atlantic.

Although, of course we cannot be said to be a water power country there are many small falls and streams that could be partially utilized. In the hilly districts such as those of Wales and Scotland, are many such, and some have been partially harnessed. But we still remain, as the Premier said the other day, the country where the least use is made of the power of its waterfalls and streams. But I know that I am here touching a thorny subject, and it savours almost of sacrilege to advocate before a Naturalists' Society, of all people, even the slightest interference with the works of Nature. But perhaps we are inclined to be a little too sensitive on this point. At the present moment a project is on foot to harness some of the streams running down from Dartmoor for the production of electricity. Quite reasonably, I think, great anxiety is felt by those who love Dartmoor and its beauties, and violent hostility to the scheme has been aroused. Personally, I share in the anxiety, but not necessarily in the hostility. The fact is that there is a right way and a wrong way, to do the work, and the right way is, whilst making use of the energy, to have regard at the same time to the preservation of the beauties of the surroundings. Can this be done? I should answer yes. Possibly some small proportionate part of the theoretical power *may* have to be sacrificed, but this would be insignificant. Numerous examples come to one's mind, for instance, many people rightly regard Lynmouth as one of *the* beauty spots of the world, yet the Lyn has been harnessed for nearly thirty years and has furnished the power for producing the electricity used for lighting the twin villages; and again the Fall of Foyers on the shores of Loch Lomond has long served to run Aluminium Works. I do not think the Swiss valleys are made less beautiful by the large numbers of power plants scattered amongst them, or the large falls of Norway less impressive because of the useful purpose to which some of them are put. And yet in the latter country are, or will be, some of the largest water power installations in the world. Thus at Odda is an installation of 65,000 horse power, whilst at Aura the total capacity was about 250,000 horse power. Both these plants are run by the Alby Carbide Factories, Ltd., a company formed for utilising some of the Nitrogen of the atmosphere for the manufacture of Nitrogen

Compounds. In this regard Niagara struck me in two different ways. At some distance below the Falls on the American side is what is called the Milling district—a number of mills driven by water power. Seen from the Canadian side, this forms an ugly blot on the landscape and detracts from the beauty of the surroundings. Each mill seems to have made its own plans irrespective of any other, and the waste water runs down the side of the cliff from the various culverts, giving the appearance of so many drains from the buildings above. This gives an example of the wrong way of doing things, but on the other hand up at the Falls themselves the beauty did not appear to me to be in any way affected by the withdrawal of the water or the erection of the buildings of the power house.

Our attitude may, therefore, reasonably be that, whilst we wish for the harnessing of some portion of the energy of our moorland and mountain streams, we want at the same time to preserve their natural beauties.

But the most important store house of the energy of moving water has yet to be dealt with, viz., that of the tides. Here the attraction of the moon is more powerful than that of the sun in producing the diurnal ebb and flow. The figures given in regard to the power of rivers were large, but in reference to the tides they become stupendous.

Twice daily an incalculable amount of water moves over the greater part of the earth's surface. The speed with which the tidal wave runs round the ocean varies very much ; thus it has been calculated as 600 miles per hour in the Atlantic and 510 per hour in the Pacific Ocean. But near land it is much less ; thus from the South of Ireland to the North of Scotland it has been measured as equal to 52 miles per hour only. But where the channel through which the tidal wave passes suddenly narrows, as when it rushes up a river, the speed becomes very great, and the power tremendous. In this way the terribly destructive "bores," which are observed at or near the mouths of certain rivers in many parts of the world are caused. Of course the mass of water moved twice in the 24 hours is practically incapable of estimation. But many calculations have been attempted. One of the simplest of these relates to the enclosed Bay of St. Michel in Northern France, with its solitary island forming St. Michel's Mount ; it has been computed that at Spring Tides more than 400 cubic miles of water rush into the Bay, whilst even at the lowest neap there is not less than 200 cubic miles more in the Bay at high than at low water. Since one cubic mile of sea water weighs approximately 4,200 millions of tons, we can agree that a fairly considerable weight of water is being moved.

It has been stated that so far as mountain streams and waterfalls are concerned, we are not a highly favoured country, but the case is quite different when we consider the Tidal Energy. In this respect we are most fortunate. Our extensive sea-board gives abundant contact with the motive power, and our geographical position allows of free play to the tidal wave. Especially is this the case in the immediate neighbourhood of our own city. The rise and fall in the Bristol Channel is greater than that in almost any part of the world, and is only exceeded by that in the Bay of Fundy in North America. In addition there is only a very small part of our long coast line where we have less than a 10 foot rise.

We can possibly get some conception of the enormous mechanical power involved by a simple calculation. Imagine yourself standing on the deck of a ship at anchor in King Road, looking out on the top of the flood of one of the 40 foot Spring tides which sometimes occur. Then recollect that in order to raise the water under *every square yard* of the surface on which you are looking there has been expanded 450,000 foot lbs. of work, or supposing it has taken 6 hours for this water to rise, then on every small square of 15 foot side there has been expended One Horse Power of Energy working continuously during the six hours. Remember the great expanse of water at high tide between Portishead and the Monmouthshire bank of the Severn, and the above calculation gives some idea of the enormous amount of energy which twice daily is offered by Nature for our acceptance, not even one foot pound of which is being utilised at present.

More than five and twenty years ago I published a series of calculations in which I endeavoured to show that from the tidal waters of the Avon we could obtain sufficient power to light a fairly large part of the city. Since that time, many improvements have been introduced in the machinery, and appliances for electrical generation. But they have all been concerned with the energy derived from coal and oil, and no water power installation has yet materialized. Nevertheless, the tides still ebb and flow and the river runs down to the sea, and I am still hopeful even after this long period, that at some not far distant date the old city will reap some advantage from the wealth that lies at her door.

One is encouraged in this hope by recent Government action. A short time ago a Committee called the Water Power Resources Committee was constituted by the Board of Trade and held several meetings at which little was done. Recently, however, the scope of its enquiries has been enlarged and it is making a fairly thorough study of the problem of harnessing tidal rivers for producing electrical power. No Committee making such enquiries could omit

from consideration our western Severn, and accordingly this river has been selected as a test case. In addition to the range of tide, the situation of the power installation is considered very favourable, as are also the facilities for the disposal of the energy when it has been successfully generated.

In a comprehensive enquiry, such as this is, many points and difficulties arise. For example, the geological structure of the district and its consideration in regard to foundations; the dimensions of the barrage required to ensure a commercial supply; and the possible interference with navigation and fisheries. All these points are being carefully and thoroughly considered, and we can fervently hope that the labours of the Committee will result in the production of a *practical* scheme that will be of great benefit to the community.

Bristol is well within the sphere of influence of the tidal waters of the Severn, and we may confidently expect that advantage will result to our city from the cheap supply of electrical current; we shall also benefit considerably from the increased transport facilities between us and South Wales which will result, because one part of the scheme is to construct a large dam strong enough to carry railway lines and a motor road, thus greatly facilitating communication between the two sides of the river.

The plan which has lately been formulated for the provision of a large regional electric power installation for the Western District contemplates drawing its energy from coal or oil. All the advantages of a central distributing centre can be retained, whether energy is derived from one source or the other, and it would seem that advantage to the public would result if the two schemes were considered together before entering upon the lavish expenditure which will be necessary for either.

There is one problem which has to be solved before any scheme for the utilization of the energy of moving air or moving water can be completely successful. That is the question of storage, so as to be able to control the regularity of the supply of power. Storage may be of two kinds—that of a head of water, and that by means of electrical storage batteries. The erection of barrages, dams, etc., illustrates the first kind, and is the most simple method of attaining the object. It is almost the only plan adopted in practice and is applicable in almost all cases; but I venture to suggest that a combination of the two methods will frequently be found to be of advantage, and it is to be hoped that experiments for improving the effectiveness of the electrical method will not be neglected.

To sum up the results of this investigation: We find that practically all our motive power is at present derived from the burning of coal, but that an enormous amount of energy is contained in moving air in the form of wind, and in moving water in the form of waterfalls, running streams and rivers, and especially in tides. That only an insignificant amount of this energy is at present utilized in England, but that the possibility of doing so is quite easy, and that the Industries of the Country require that this should be done, and done quickly.

PRESIDENTIAL ADDRESS, 1921.

"Natural Sources of Energy and Food Supply."

By E. H. Cook, D.Sc.

IT will be in your recollection that when I had the honour of addressing you at this time last year I ventured to call attention to the advantages to be derived from the utilization of natural sources of energy, especially that of moving water in our rivers and tides, and I pointed out the enormous stores of power in the waters of the Severn, the Avon and of the Bristol Channel.

It was stated that notwithstanding the fact that this matter had been brought prominently forward many years ago, no water power installation had materialised, but the hope was expressed that "at some not far distant date our old city would reap some advantage from the wealth that lies at her door." The appointment of the Water Power Resources Committee by the Board of Trade was mentioned, and also the fact that the Severn had been selected for careful consideration, and that suggestions would probably soon be made.

It was also stated that "Bristol was well within the sphere of influence of the tidal waters of the Severn, and we may confidently expect that advantage will result to our city from the cheap supply of electrical current; we shall also benefit considerably from the increased transport facilities between us and South Wales which will result, because one part of the scheme is to construct a large dam, strong enough to carry railway lines and a motor road, thus greatly facilitating communication between the two sides of the river."

This was as far as the subject had developed at that time, and I was fortunate in being able to give you so early an account of the work of the Water Power Resources Committee. But the consideration of the matter was continued, and finally the report was issued on November 26th last. Considerable publicity has been given to this and the proposals have been much discussed. The scheme is the same as described to you last year. The key suggestion is to build a Concrete Dam across the river at a spot near the New Passage. Automatic flat sluices will allow the rising tide to push them open, but will bay back the tidal water when it commences to return. The turbines and generating machinery will be placed in chambers built in the dam. In our discussion of the subject on the last occasion it was pointed out that the great difficulty in utilizing the energy of running water was the intermittent nature of the power. In the Severn scheme it is proposed to get over this by providing a large high level lake in the hills just north of Tintern, into which water will be pumped

by means of powerful centrifugal pumps, operated from an enormous power house on the banks of the Wye. When the turbines in the dam cannot be worked because of the state of the tide, power will be obtained from the water in the lake.

If such a result can be achieved the project will provide the largest water power installation in the World, for it will give over half-a-million horse-power during a 10-hour day. The Amalgamated Niagara Falls Power Company, which is the present largest, has a capacity of only 385,500 horse-power. The power developed, if this scheme is successful would be equal to that which would be obtained from the burning of from three to four million tons of coal per annum ; this could then be used for other purposes. The Concrete Dam would afford the means of improved railway facilities between the districts on either side of the Severn, and it is suggested that even if the project for utilising the water power is not persisted in, the Dam will be erected to meet the requirements of the railway. The complete scheme includes, in addition, a gigantic locked basin for shipping purposes on the Upper Severn, a large portion of which will be available for the accommodation of ocean-going steamers.

So far as I have seen no authoritative financial estimates have been put forward. Practically the only statement made has been that "the cost for generation at present-day prices" would be "a little over a half penny per Board of Trade unit." This is very vague, and I must say very disappointing. Twenty-five years ago it was stated that at Niagara Falls electricity could be sold at a profit for one-seventeenth of a penny per Board of Trade unit, whilst the works cost (i.e., coal, oil, etc., wages and repairs) of many Electrical undertakings in this country is well under a penny per unit sold. It does not even tell us the most important fact as to whether the interest on capital has been taken into consideration. We are not informed either as to the contemplated initial cost. Critics of the scheme estimate that the cost will approixmate to £30,000,000. If this be so, the interest at 10 per cent. would amount to £3,000,000. In order to earn this sum alone, I estimate that more than a halfpenny will have to be charged on each of the 3,731,000 B.T.Us., which is about the equivalent of 500,000 horse-power working for ten hours. It appears probable that there is some error in the figures somewhere, but lack of information prevents it being traced. The scheme has, however, only been stated as a whole. It is therefore premature and perhaps unfair to discuss details when those details have not been published.

Considerable anxiety has been caused in Bristol by the proposals. This has arisen from the fear that a rival port would be set up at our very doors, and that the interference with the free

flow of the waters of the Severn, especially the flood waters, would cause the silting up of the present entrance to our Docks and river. The large investment of the citizens of Bristol in their Dock undertaking make both these objections of great importance, and they will, no doubt, be most carefully considered before the proposals are carried out. One would be inclined to consider the rival port as a sentimental objection which would never have much foundation in fact. And in regard to the formation of mud banks it is almost inconceivable that any body of practical engineers, unless absolutely ignorant of the locality, can have begun to consider the subject without remembering the mud of the Bristol Channel. The account for dredging paid by Bristol amounts to nearly £40,000 a year at present, and it seems probable that this would have to be increased, if the scour from the Severn was hampered. Much of the criticism, however, seems to be based on the assumption that the flow of water down to the sea will be entirely prevented. Of course, that is erroneous. The same amount of water will have to get away in the future as in the past, but it is quite possible that it may not have the same scouring power. Only experience can decide this. But this is a matter that must be gone into by the engineers before starting on the work. It may not be as bad as some people seem to think, and, at any rate, cheap power will be available for reducing the cost.

As the first serious attempt to utilise a small portion of the vast water power which has been allowed to run to waste for so many years I think the scheme ought to be welcomed and that instead of turning it down as impracticable we should all endeavour to overcome the difficulties which are inherent in big suggestions of this kind.

The utilisation for human purposes of some of the wasted energy of the universe is becoming of more and more importance. There can be no doubt that increased productiveness is required at the present time and will be required even more in the future. More especially is this the case with food-stuffs. The population of the world is increasing daily but neither the area under cultivation nor the food products yielded show a corresponding increase. Prominent attention was first called to this subject by Sir William Crookes in his Presidential Address to the British Association at the meeting in Bristol in 1898. Some extracts from that remarkable address will be read with interest at the present time. For example, Sir William says: "Many of my statements you may think of the alarmist order; certainly they are depressing, but they are founded on stubborn facts. They show that England and all civilised nations stand in deadly peril of not having enough to eat. Land is a limited quantity, and the land that will grow wheat is absolutely dependent on difficult and capricious natural phenomena.

I am constrained to show that our wheat-producing soil is totally unequal to the strain put upon it."

He then proceeds to examine the area and productive capacity of the wheat-producing lands of the world, and concludes : " Should all the wheat-producing countries add to their area to the utmost capacity, on the most careful calculation the yield would give us only an addition of some 100,000,000 acres yielding 1,270,000,000 bushels, just enough to supply the increase of population among bread-eaters till the year 1931.

During the years which have elapsed since this address was written, many changes, which could not have been foreseen by Sir William Crookes, have taken place. Fortunately some of these have added to the available store of food-stuffs for the inhabitants of the world and it is reasonable to expect that fresh discoveries and mprovements will effectually prevent the gloomy prophecy from becoming true. Moreover, the rate of increase in the bread-eating population of the world, which at the time Crookes wrote was over 7,000,000 per annum, has decreased slightly since. It is remarkable, however, how little change has taken place in some particulars since the paper was written. Thus in 1897 the yield of wheat per acre in the United Kingdom was 29.07 ; whilst in 1919 it was 29.2 bushels per acre. The average world yield was taken by Crookes as 12.7 bushels per acre. In 1919 so far as statistics could be obtained it gave 12.9. But the area under cultivation has increased. Thus in 1897 the United States produced 64,000,000 quarters, but in 1919, 114,000,000 ; the United Kingdom in 1897 gave us 7,000,000 quarters, and in 1919 8,665,000.

The provision of the necessary food is absolutely essential if the race is not to become extinct, and what has been traced out in regard to wheat is applicable to other articles of food. The problem is one of elementary conditions ; a limited area for producing and an unlimited production of units for the consumption of the products produced. Or in other words whilst the land capable of cultivation cannot increase beyond well-defined limits, the population may go on increasing indefinitely.

The fixation of the year 1931 is simply accidental, but there is no escape from the reasoning, and there can be no doubt that if things had remained as they were in 1898, or if they remain as they are now, in the time of the next generation the shortage will be acutely felt. But fortunately the lines along which we must work in order to prevent this catastrophe are clearly indicated and capable of simple expression ; the land must be made more productive. It was said many years ago that he who made two blades of grass grow where one had grown before was a great benefactor of the human race. It is in this direction that work must be done.

And there is abundant scope for improvement. For example, in 1919 Denmark made its wheat fields yield 47.5 bushels to the acre, Great Britain 29.2, whilst Australia only 5.9. Therefore, taking the total yield for 1919 we find that if the American fields, for instance, whose yield was 12.5, can be made to give the same amount per acre as Denmark, they alone would produce more than *twice as much* as the whole production for 1919, whilst if they only came up to the yield of Great Britain the total amount would be greater than that of all the other countries put together. It should however, be mentioned that these figures had to take no account of Russia, from which country statistics were not available.

Provided good and suitable seeds are selected the reasons producing the different amounts yielded are practically three: (1) Amount of work devoted to cultivation; (2) Climatic conditions, and (3) Provision of suitable plant food in the form of manure.

The first of these ought to need no emphasising, and yet we are living in such peculiar times that extraordinary ideas seem to have taken hold of many people. The necessity for work, if we are to gather the fruits of the earth in due season, seems to be ignored. It is absurd to expect that the yield of anything that requires labour will be the same if the total amount and quality of the work put in is indefinitely reduced. Nature is profusely generous, but she is just, and therefore extremely hard on slackers. There is almost always a direct proportion between the amount of labour expended on the land and the amount of the material produced by its cultivation. There is much truth in the legend of the farmer who thought he had gold on his farm and dug to a great depth in order to get it. He did not get the gold by digging, but got it indirectly in consequence of his labour because of the increased production.

But it is particularly in regard to the third reason that practical science in the utilisation of natural sources of energy is destined to play an important part in securing our food supply. It is of course common knowledge that particular manures are specially suitable to particular plants. In order to produce to the best advantage, some plants must have manures containing potash, others phosphates, and others nitrogen. But since we are considering for the present the growth of wheat, we need only confine our attention to the manure required by that cereal. Pre-eminently that is the element Nitrogen. Every grain of wheat contains about $1\frac{3}{4}$ per cent. of Nitrogen, consequently every 100 tons of wheat takes away from the land about 35 cwt. of Nitrogen, and probably causes the breaking up of about $11\frac{1}{4}$ tons of nitrogenous substances contained in the soil. The supply of this substance is, therefore, necessary if wheat is to be grown. Practical farming soon discovered that it was not profitable to grow the same crop on the same untreated

land for many successive seasons. It was left, however, for science of comparatively recent years to show that this was due to the removal from the soil by the growing plant of some constituent which it needed for its growth. When the land ceased to contain this constituent the plant ceased to grow upon it. More than 2,000 years ago at least the rotation of roots, barley, clover and wheat was practised by the agriculturist. It remained, however, until the latter part of the nineteenth century for science to explain why clover and other leguminous plants caused this improvement in the yield of wheat grown on the same land in the following year. Then it was discovered that these plants harboured on their roots enormous colonies of bacteria which possessed the power of fixing atmospheric nitrogen in the soil for the use of the subsequent crop. But when attempts have been made to use this discovery on the large scale, they have generally not succeeded. The land has become what is known as "clover sick" and barren, and this simple remedy is therefore not a practical one.

Many sources have been called upon to supply the necessary element. For many years guano, a deposit containing readily available nitrogenous and phosphatic material was used. But the supply was practically exhausted several years ago. The sulphate of ammonia produced as a by-product of the Coal Gas industry has been called upon, but the amount produced is not and never can be sufficient to meet the requirements. A much more extensive source has been found in the deposits of nitrate of soda found principally in the practically rainless districts of South America, near Chili. The substance has been the only one employed on a really world-wide scale for some time. It has been largely used as will be readily understood when it is said that twenty years ago the exports were more than 1½ millions of tons, and this has largely increased since.

At this rate the deposits cannot last long, and it was estimated many years ago (1897) that at the rate of a million tons per annum exhaustion would occur in about fifty years. An exact measure of the influence of nitrate of soda in increasing the produce from the land has been established by the classical experiments of Sir John Laws and Sir Henry Gilbert at the experimental farm at Rothamstead. Here in careful experiments extending over 26 years it was shown that an increased yield of from 11.9 to 36.4, or 24.5 bushels per acre was produced by a dressing of 5 cwt. of nitrate of soda. Therefore 22.86 lbs. of nitrate produce an extra amount of 1 bushel. Thus a numerical relationship is established between the amount of the produce and the amount of manure used and it would seem that the increasing need of the world's population is dependent upon the provision of an adequate amount of nitrate of soda or other similar substance. How is this substance to be obtained? The

mineral deposits of nitrate of soda which have taken thousands of years to form, must ultimately and probably shortly be exhausted. We are therefore compelled to look around for other supplies. One source which would be quite adequate was brought prominently forward by Leibig 70 to 80 years ago. He was very plain spoken and told us that "such a sinful violation of the divine laws of Nature" as we committed by sending our sewage to the sea, "could not for ever remain unpunished," and that "the time will probably come for England sooner than for any other country, when with all her wealth in gold, iron and coal she will be unable to buy one-thousandth part of the food which she has during hundreds of years thrown recklessly away." There can be no doubt about the truth of this, but any adequate and practical scheme for utilizing the valuable constituents of the sewage and drainage from our towns has yet to be discovered; and we still continue our colossal extravagance of pouring down our water courses every year material which has a potential value in fixed nitrogen alone of about £20,000,000.

The ultimate source of all the nitrogen contained in the animal, vegetable and mineral matter of the earth is the atmosphere. Here it exists in the free state mixed with oxygen. Whilst free it is of no value as a plant food, but combined, as already stated, it is absolutely essential. Whilst in its free, pure state it is quite inert, but when chemically united with other elements it is the central or pivotal element of the most violent substances, such as cordite among explosives, and prussic acid among poisons, and of foods such as fibrin and albumen. Many attempts have been made to fix the atmospheric nitrogen by what may be called purely chemical means. These have not been successful. But it was shown many years ago that by employing a sufficiently high temperature, such as that of the electric spark and a suitable arrangement of apparatus, combination could readily be brought about and nitric acid produced. This, however, requires the expenditure of energy in order to produce the electricity. If this energy is produced from coal by the intervention of steam engines, the cost is prohibitive, but if the energy of running water is available the process becomes practicable. Already the manufacture of fertilizers on the large scale has begun, and the success of the Nitrogen Fertilizers Co., Ltd., seems to show that the method is a good commercial proposition. Large and powerful works have been erected in Sweden and Norway for the manufacture of Nitrolim and Cyanmide, which are the equivalents as manures of the Nitrate of Soda of Chili. In fact, from many points of view this utilization of the nitrogen of the atmosphere may rightly be regarded as the most important key industry of the world.

Within the last fortnight an announcement has been made, in a non-scientific journal certainly, but with details which seem to convey some amount of conviction at any rate, that British scientists "have at last fully penetrated the secrets of extracting nitrogen from the air by *chemical methods* requiring much less expenditure of power than those used in other countries." What the exact method is we are not told, but the essential point for my purpose at the moment is that power is required. Thus an abundant supply of energy is necessary. May not the Severn scheme or some modification of it give us that power on a cheap scale? Thus in addition to driving our machines, the moving waters of the Bristol Channel may help to cheapen our food.

But there is another way in which it is possible that the supply of a large amount of electrical energy may assist in the provision of a more abundant supply of essential food stuffs. This is in stimulating the growth of the plant by the direct application of the electricity. The processes going on in a plant during its growth are extremely complicated and varied. There is no laboratory in the world so perfect as the plant cell, and no mechanism so perfect as that which places the individual particles in their proper relationship to each other. In these complicated changes it is quite reasonable to suppose that an electric current or electric influence may exercise either an accelerating or a retarding action. Sundry experiments have been made from time to time with a view to discover whether any, and if so what results could be produced. At the British Association meeting in 1898 I described at some length a series of experiments that I had been conducting for several years previously, and at the same meeting Prof. Selim Lemstrom, of Helsingfors, in Finland, described his experiments and observations upon the same subject. A very wide field was covered and the results obtained, considering the different methods adopted and the widely varied climatic conditions under which they were made were remarkably similar. But we were not the first experimenters in this field. So long ago as 1746 Maimbray, in Edinburgh, made the first experiment which consisted in electrifying two small myrtle trees which were thereby caused to put forth branches and blossoms much earlier than similar trees which had not been so treated. After that several experimenters tried the effect and reported similar favourable results. So far as I have been able to find, none of these men were British, but in 1885 Mr. Richard Owen, of London, took out a patent for a "Galvanic Plant Invigorator." From the description of this invention I do not think Mr. Owen can have made much money out of his discovery. All the experiments may be said to range themselves into two classes:—(1) Those in which the electricity is passed through the ground in which the seeds are growing; and (2) those in which the electricity is applied to the plants by being discharged through the air from

an overhead system kept charged at a high potential. In addition to these methods I also used one which consisted in electrifying the seeds before they were planted. It would be tedious and beside our present purpose to explain in detail the plans adopted in these experiments. Judging from one of the latest publications on the subject: a paper by Jorgensen and Stiles in "Science Progress," for April, 1918, only a few experiments on new lines have been made since the British Association Meeting. Some of these have had reference to the influence of the electricity on certain plant processes, such as assimilation, transpiration, etc., but no new facts of importance have been revealed. It is true that a large number of experiments have been made, but almost all have been repetitions of those made by former experimenters. By far the most hopeful results have been obtained within the last few months by Sir J. Chandra Bose, who has been making investigations into Plant Physiology and by means of an instrument called the magnetic cres-cograph, which he has invented, is able to render visible the growth actually taking place. With this instrument he has tested the behaviour of certain plants under the influence of stimuli, including of course electricity. The work has not proceeded very far, but already some of the abnormal results which bothered us in the earlier days have been explained, and it is hoped that our knowledge of the laws of plant growth may be much extended.

Although some investigators, the great Dutch Scientist, Ingenhouz, for example, who in 1788 declared that the stimulation of vegetation by electricity was impossible, have not obtained positive results, there is now a vast amount of evidence showing that under certain conditions growth is accelerated and increased by the use of electricity. Some observers have obtained extraordinary results. Thus Lemstrom states that in 1897, on a farm in Finland, he got "increases in the seeds of at least 40 per cent., in the roots from 25 to 75 per cent. and with fruit (raspberries and strawberries) about 75 per cent." Others have reported similar increases. In my own case I have not been so successful, but my results have given from 15 to 30 per cent. increase obtained from experiments on the seeds both before and after planting and from high tension discharge.

Although the details remain to be worked out and the conditions thoroughly investigated, it is certain that an increased yield can be brought about by electrical influence. Suppose we take this as equal to 10 per cent. only, and suppose it had been successfully applied to the wheat fields of the United Kingdom, we should have added 866,000 quarters to the yield in 1919, making the total 9,531,500 qrs. and providing at 5 bushels per head; that is (in England) about the wheat consumption per annum, bread enough to feed 1,384,000 human beings for one year. The total increase

in the population of the United Kingdom during the period of 1901 to 1911 amounted to 3,393,703. This augmentation in the supply would thus cover the increase for about four years. But in order to take advantage of this mode of increase we must have an abundant and cheap supply of electrical energy. This can only be provided by utilizing natural sources in the shape of moving air and water. The Severn scheme is an attempt to do this, and if it can be carried to a successful issue the supply for this district ought to be forthcoming.

We may therefore ask what are the suggestions which arise out of this "exploration" (I believe that is the favourite word of the present-day politician) of the connection between natural energy and wheat supply. Firstly, that some of the abundant and cheap supply of electricity *promised* by the adoption of the Severn Barrage scheme or an equivalent, should be used for the fixation of atmospheric nitrogen for the purpose of manufacturing artificial nitrogenous manures.

Secondly, that in the neighbourhood should be established in the first instance, an experimental farm freely supplied with electrical power, where electro-culture experiments on the large scale could be carried out, with the view of placing upon an exact basis the conditions governing the acceleration of the growth of plants produced by electricity.

The first suggestion would immediately aid the amount of our wheat crop, and the second would place in our hands the means of doing the same thing in the future.

Finally, our investigation shows that there is no cause for gloom or despondency as to the future of our bread supply. The area of suitable land may be limited, and the increase of population become very great, but the plans mentioned are quite capable of counteracting these drawbacks and provide wheat anough to feed a vastly increased population for many years to come.

We have only to throw off our present obsession and to remember that "Labour is the lot of man" and that nothing is obtained without it.

THE INFLUENCE OF ENVIRONMENT ON THE DEVELOPMENT OF PREHISTORIC MAN.

By L. S. Palmer, M.Sc., Ph.D.

I.—Introduction.

The following graphical methods of recording certain data of prehistory may be of interest as they emphasize pictorally the close association between the stages of man's early evolution and the peculiarities of his changing environment. This dependence of man upon his surroundings can be seen by simultaneous changes in the slopes of curves which represent, respectively, man's progress and the variations in the climate and the physical conditions under which he lived.

It has been realised that man's intellectual or cultural development had taken place much more rapidly than his physical or anatomical development. A graphical method of recording prehistoric events might possibly disclose, by a comparative analysis of the respective graphs, some of the causes for these different rates of human progress.

Of the customary sub-divisions of prehistory the Azilian period is generally considered a transitional period, after which the standard of human cultural attainments was much higher than in the preceding ages. A graphical record of prehistory should depict such transitional periods by changes in the slopes of the graphs; and, by comparison with curves of other contemporary events, may possibly indicate some cause for the variation in the rate of development at these particular critical periods.

II.—The Curves of Human Development.

Such graphs necessitate quantitative data. It is possible with certain criteria of human development to obtain numerical relations from which curves showing the required rates of progress can be plotted. The exactness with which these curves represent human evolution will depend upon the exactness with which the chosen criteria are a measure of man's physical or intellectual development. The Simiidæ (the Chimpanzee in particular) have been taken as a convenient standard or unit of comparison.

For physical development two criteria, based upon existing skeletral remains, have been considered:—

(1) Anatomical indices.

(2) Brain capacity.

From the similarity in the two sets of figures, the fact that brain capacity is not a test of intellectural attainment is emphasized.

For intellectual or cultural development the following have been considered :—

(1) The number of different types of implement known to have been in use at any given period.

(2) The number of occupations at which man was employed.

(3) The number of kinds of material which were in use during the period in question.

The numerical results from these five criteria are shown in Table I. The average of the first two columns is plotted in Fig. 1, whilst Figs. 2 and 3 are obtained from the last three columns. The values in column 1 are the average of various anatomical indices compared with similar measurements of the Chimpanzee. In the case of the first three types of men the number of indices considered is naturally limited by the scanty remains available. The high values at the end of the last columns are approximate values only. The two occupations at the top of column 5 are those necessary solely for the preservation and maintenance of the species, namely, fighting and hunting. Man, in addition to these, made tools. Neanderthal man in all probability also used skins as clothing and cooked food ; a possible consequence of the oncoming of the last glacial epoch.

Other qualitative facts bearing upon the steepness of the slopes are indicated along the curves.

TABLE I.

Type.	Relative anatomical indices.	Relative brain capacity.	Mean.	Number of implements.	Number of occupations.	Number of materials.
Chimpanzee ...	1	1	1	0	2	1 ?
Pithecanthropus ...	1 ?	2.4	1.7	1	3	2
Heidelberg	1	–	–	5	3	2
Piltdown	1.5	3.0	2.2	6	3	2
Neanderthal (Gib.)	3	4.0	3.5	12	5	4
Neanderthal (Spy)	6	4.1	5.0	–	–	–
Cro-magnon ...	9	5	7	24	18	8
Brunn-Grenelle ...	7.5	–	–	–	30	12
Neolithic	–	4 to 5	6 to 6.5	35	70 +	15
Bronze	8.0			70 +	300 +	28
Iron	8.0			150 +	300 +	35 +
Modern	8.5	5.2	6.8	10,000 +	10,000 +	200 +

Fig. I.

PLEISTOCENE AGE.

Curve of Human Progress in Europe (Anatomical or Physical Development)

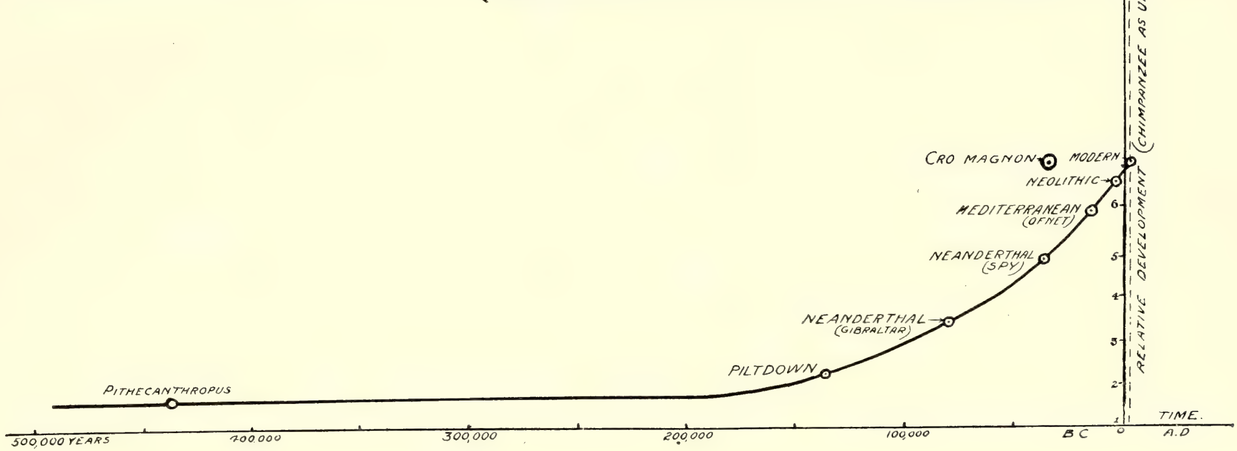


Fig. 2.

PLEISTOCENE AGE.

A.- Curve of Human Progress in Europe. (Cultural or Intellectual Development.)

B.- Temperature Curve.

C.- Relative Areas of Dry Land.

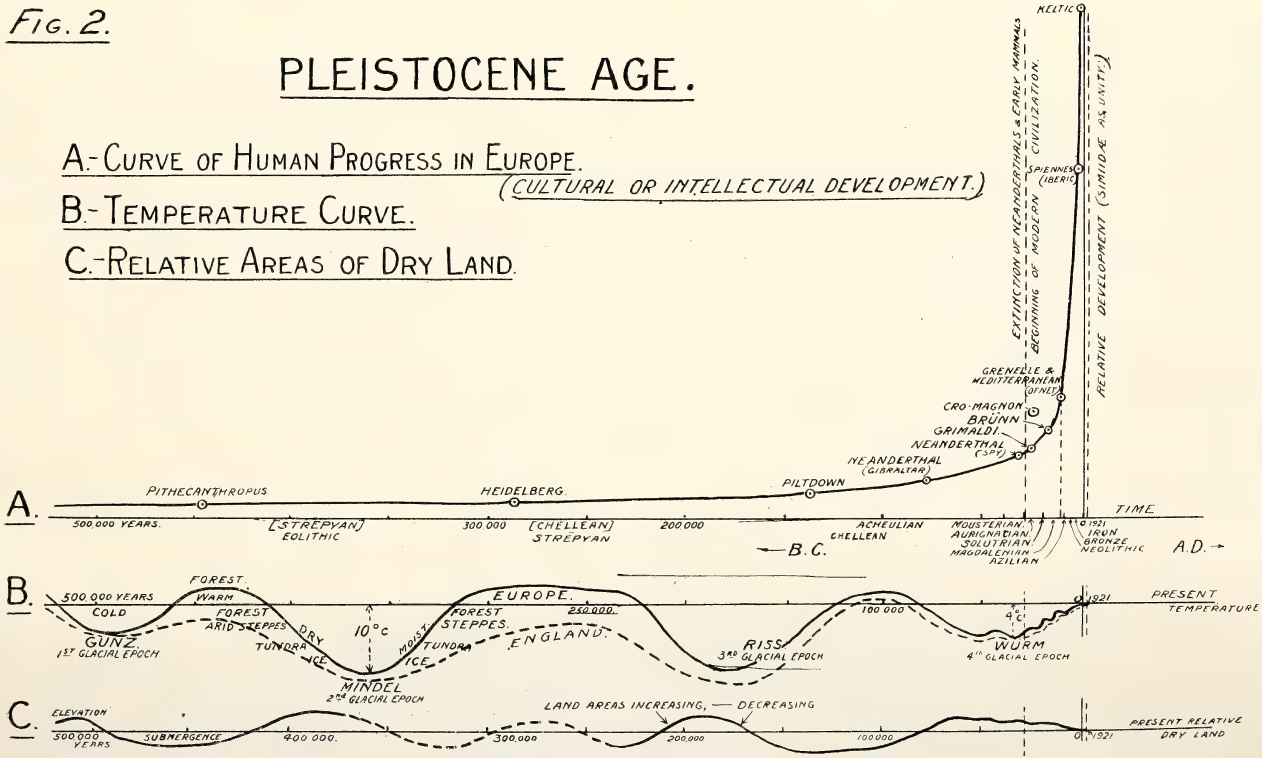
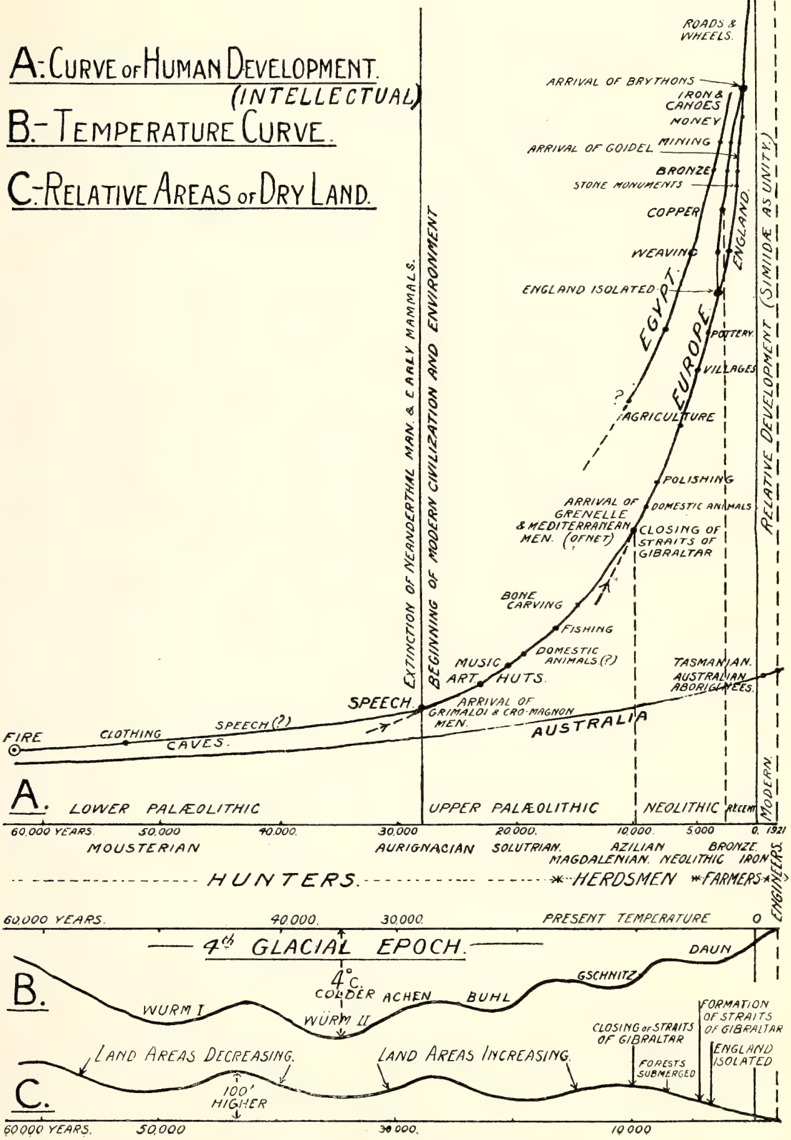


Fig. 3.

4^{th} GLACIAL EPOCH.



III.—The Curves of Environment.

Fortunately the environmental conditions which exerted most influence upon man's development are those about which we can obtain the most exact information. They are:—

(1) Climate and

(2) Relative dry land areas.

Both these factors can be more or less accurately determined for a given district from geological, astronomical and physical evidence.

The climate is represented by the Temperature Curve at the bottom of Figs. 2 and 3. The relative areas of dry land are shown by the second curve at the bottom of the same figures. Since these curves refer to Western Europe in general, they cannot be applied to any given locality in detail. They are illustrative of the principles which apply all over Europe, but which require to be modified according to the particular conditions of any given district. Thus a broad modification for England will be that indicated approximately by the dotted temperature curve. This change is due mainly to the position of England compared with Western Europe in general. This lower curve may also be applied to Norway. Such a curve explains partly the lack of similarity between the European glaciations of Penck and those for which there is direct evidence in England and Norway. The first occurrence of inter-glacial warm fauna in England is to be found in the higher Thames Valley terraces and at Cresswell Crags, where the straight tusked elephant and "Forest bed" flora are associated with Chellean and Acheulean flint implements. Prior to this England seems to have experienced arctic conditions with no evidence of human occupation. These differences might be anticipated from the two temperature curves in Fig. 2. The dotted temperature curve for England, if drawn on Fig. 3, will also be in agreement with the fact that Aurignacian and Solutrean man have not been found in districts north of the Paviland Caves. A similar reason may account for his absence in the Alps. It is probable that warmer conditions prevailed in England prior to the Gunz Glacial Epoch, and that man was also present in the country.

IV.—Deductions from the Curves.

A peculiar point disclosed by Fig. 1 is the abnormal position of Cro-magnon man, who seems, at least physically, to have been much in advance of his time. On the whole, physical development seems to have progressed slowly and steadily. It may be mentioned that the continuity of all the curves does not indicate any continuity of descent. The data at present available is insufficient to draw separate curves for each type of man.

From the lower curves of Fig. 2, a comparison of the position of the bends emphasizes the dependence of dry land areas upon the quantity of water locked up as ice. For some particular localities this comparison cannot be made since a lowering of the land may have been such that there was no change in the relative dry land area during an arctic period. The land area may even have decreased if the subsidence more than compensated for the lowering of the normal sea level. Similarly, if the land rises, land areas may increase during the usually moist periods following an ice age. An example of this can be seen in the decrease in size of the Littorina Sea about the same time that the Straits of Dover were formed.

The most interesting deductions arise from a comparative study of the development curves of the three figures. The Australian aborigines do not appear to have experienced the same mental stimulus as in the case of the European peoples. It may have been that the Australian was prevented from responding to such stimulus owing to adverse environmental conditions. A conspicuous change in the slope of the curve of European intellectual progress occurs in Aurignacian times and also in the Azilian period where the curve again rises sharply. A third advance took place with the introduction of metal after Neolithic times. A further point of interest is the temporary isolated progress in England after the formation of the Straits of Dover. Not only was there no copper age in England, but a time interval occurred before Continental knowledge passed into the island. No such retardation can be noticed after the increased road and water transport facilities of about 500 B.C.

From Fig. 3 it appears that the closing of the Straits of Gibraltar, probably about 25,000 and 10,000 B.C., and the formation of land bridges from Africa to Italy was closely associated with the arrival of new peoples from Africa and, for similar reasons, from the East. These facts together with the retirement of the ice and the extinction of the early types of mammals were probably some of the main causes for the rapid cultural development which occurred at Aurignacian times. In addition, the ability to speak and to communicate ideas was, from anatomical considerations of Neanderthal skulls, much greater than in the Mousterian period. The introduction of art and possibly the harp (contemporary with the bow and arrow) with which we can safely couple chanting and dancing, all point to a progress of quite a different rate from the steady slow advance of the earlier cave men. In fact modern conditions of life and environment commenced with the Aurignacian period. The curve does not, however show a sharp bend or kink and there is no reason to suppose so great a discontinuity in man's evolution that it would be visable on the scale used for

these curves. Even Neanderthal man possessed some form of elementary religion whilst his flint implements have some characteristics (e.g., re-touching) which, though developed independently, are typical of the early Aurignacian period. An appreciable increase in the rate of progress might be expected when the power to communicate ideas by speech enabled one man to benefit intellectually (but not physically) by the experience and thoughts of other members of his community. Thus, after this stage, cultural progress would be the result of the accumulated knowledge of the many, whilst physical progress would be the result of the isolated effort of the individual. We may roughly consider intellectual progress to have taken place "geometrically" whilst physical progress has taken place "arithmetically." The fact that the curve of Fig. 1 is not therefore a straight line is due to inherited physical tendencies being, to some extent, the accumulated result of more than one generation, and not merely an additive process from one individual to the next.

At Azilian times a further increase in intellectual progress took place. From the lower curves of Fig. 3 it can be seen that similar changes in the physical conditions existed. They were less marked and there was no conspicuous change in the types of mammals. It therefore appears from these considerations that the Aurignacian period was a time of greater transition than the Azilian period. The occurrence of both transitional periods owes much to the favourable geographical conditions then prevailing, and also to man's state of evolution which enabled him to take advantage of them.

V.—CONCLUSIONS.

1. There was a fundamental difference in the rate at which prehistoric man had developed physically and in the rate at which he had progressed intellectually.

2. The former rate was comparatively slow, being dependent on the effort of the individual, whilst the latter rate became more and more rapid as man became more and more capable of taking advantage of the intellectual attainments of his fellows.

3. The occurrence of environmental conditions favourable to man's progress was a probable cause of the Transitional Periods, during which the rate of intellectual development abnormally increased.

4. The curves also suggest that the Aurignacian period was the first and greatest advance after which a continual progress towards modern conditions took place. The Azilian period, though similar, seems to have been of a less revolutionary character since it was an increase in the rate of progress towards present civilization rather than a change from ancient to modern conditions.

Bristol Botany in 1920 and 1921.

By JAS. W. WHITE, F.L.S.

IN recent years the coastal mud-flats on our side of the Bristol Channel, from some unknown cause, have undergone changes in configuration so extensive that (as I am informed) a re-arrangement of guiding buoys has become necessary. Another remarkable result is that a large acreage of mud between Brean Down and Burnham is now covered with vegetation. Mr. H. S. Thompson, who has undertaken an ecological and photographic survey of this area, reports that far out on the mud seaward of Berrow there is much *Salicornia dolichostachya* Moss, a new plant for this district. The grass *Glyceria maritima* is abundant and flowers during several weeks, although submerged in sea-water at every tide. Mr Thompson also detected, opposite Berrow, several large patches of *Spartina Townsendi.* The probability is that these originated from detached roots washed down Channel *via* Sand Point and Brean Down from the foreshore below Clevedon, 15 miles N.N.E., where *Spartina* was planted about the year 1913.

It is still impracticable to publish more than a small number of the reported notes on our rarer plants.

Ranunculus Lingua L. In an overgrown pool N. of Charterhouse-on-Mendip ; approachable as a result of the great drought ; *H. J. Gibbons.*

Fumaria Martinii Clavaud. (*F. paradoxa* Pugsley.) Cultivated land on Combe Down, Bath ; *Mrs. Sandwith.* See *Journ. Bot.*, Jan., 1921. A very rare colonist, hitherto only known in Cornwall and Guernsey.

Polygala calcarea F. Schultz. Over several acres of hilly, rough pasture at about 300 ft. above Combe Hay, at least half-a-mile from the original station. An important extension of the plant's area in the district ; *H. S. Thompson.*

Cerastium arvense L. Limestone outcrop on the edge of Limeridge Wood, Tickenham, S. ; *C. and N. Sandwith.*

Sagina nodosa L. In plenty near the top of Backwell Hill, S., for more than 200 yards along a grassy lane and on the open moor, Sept., 1920 ; *H. S. Thompson.*

Trifolium squamosum L. (*T. maritimum* Huds.). Re-discovered in St. Brody's station on the Severn bank below New Passage by *C. and N. Sandwith.* By the Channel, near Easton-in-Gordano ; *H. J. Gibbons.*

Lathyrus hirsutus L. Casually in a garden at Webbington, S ; *A. E. Stephens.*

Cratægus oxyacanthoides Thuill. In a hedge on Yate Lower Common, G. one fine bush ; *C. and N. Sandwith.* By a stream near Wickwar, G. ; *Miss Roper.* New to the vice-co. *C. Azarolus* L. A native of the Mediterranean region, established a short distance from Shapwick Station, S. ; and reported by several botanists.

Geum intermedium Ehrh. Roadside at North Widcombe near Bishop Sutton, S. ; *Miss Roper.*

Potentilla argentea L. Exposed limestone on the Cadbury ridge beyond Tickenham, S. ; about a mile from Rev. E. Ellman's locality on that ridge and proving apparently that this plant may be native on limestone ; *C. and N. Sandwith.*

Epilobium hirsutum L. There was noticed last September along a ditch-bank on Kenn Moor near Yatton, by *Mr. H. S. Thompson,* a remarkable monstrosity of this species in which flowering tops were replaced by heavy vegetative masses concealing rudimentary or abortive flowers. Mr. W. C. Worsdell, consulted on it, reported that the phenomenon of inflorescence being replaced by vegetative growths is widespread, and might occur with any plant. Cause unknown. No trace of injury by fungus or insect could be detected. *E. montanum* f. *verticillatum.* One plant in the Zoological Gardens, Clifton, G., and another in a lane at Chewton Keynsham, S. ; *C. and N. Sandwith.* Also at Nailsea ; *Miss Roper.*

Crithmum maritimum L. A clump amongst stones at Avonmouth Dock, G. ; *Miss Roper.*

Viscum album L. On a Mountain Ash at Flax Bourton, 1920 ; *Mr. F. Tutin.* On *Robinia* at Publow Leigh, near Pensford ; and on Ash at Chewton Keynsham ; *Miss Roper.*

Myriophyllum alterniflorum DC. Pond on Yate Common, G. 1910 ; *Herb. Bucknall.* Confirming the old records for vice-co. 34.

Antennaria dioica Gaertn. Loxton Hill, S. with *Filago minima,* June, 1920 ; *Miss Roper.*

Vaccinium Myrtillus L. Windmill Hill, Portbury, S. ; *Miss Roper.*

Symphytum tuberosum L. Wood by Compton Greenfield, G. ; *Miss Roper.* Wood near Mells, S. *H. S. Thompson. S. orientale* Bieb. Waste ground, Clevedon ; *Miss Livett. S. peregrinum* Bieb. About Fortnight Farm, near Bath ; *C. and N. Sandwith.*

Limosella aquatica L. was discovered last August by Messrs. H. J. Gibbons and C. Alden on the mud of a dried-up duck-pond some five miles N.E. of Bristol. The plant grows in fair quantity. Save for a locality in the Forest of Dean, this appears to be the

first authentic record for West Gloucester; and the species is new to the Bristol district.

Scrophularia nodosa L., var. *Bobartii* Pryor. On the railway bank, Black Rock Quarry, G. 1920; *Ivor W. Evans.*

Antirrhinum Orontium L. Sparingly in fields of mangold, between Yate and Iron Acton, G.; *Miss Roper* and *H. J. Gibbons.*

Stachys sylvatica L., f. *monstrosa.* The corolla tube not exserted, the perfect flowers green with reddish margins, leaves yellowish-green with red markings. Tickenham, S.; *C. and N. Sandwith.* *S. ambigua* Sm. Good specimens of this rarity in the old Cyperus ground at Walton-in-Gordano, S.; *C. and N. Sandwith.*

Leonurus Cardiaca L. By Portishead Dock. Noticed by B.N.S. members on one of the summer excursions.

Galeopsis speciosa Mill. Discovered September, 1920, on cultivated land between Ashcott Station and Glastonbury by *C. and N. Sandwith.* See *Journ. Bot.*, 1921, p. 21. This may be regarded as a recently introduced colonist. It should hold its own and spread, although the *G. speciosa* at Ebbor, years ago, failed to do so. In fact a single plant was seen a year later, on Shapwick Moor by *N. G. Hadden.*

Pinguicula vulgaris L. Re-discovered on the peat-moors of N. Somerset, July, 1920, by *T. H. Green*, who saw seven plants in an enclosure S.E. of Ashcott Station. And in another neighbouring enclosure by *H. Slater.* Very few persons have seen this Butterwort flowering in the Bristol district.

Salicornia dolichostachya Moss. A new plant for the local flora as described in the introductory note. Reported also from St. George's Wharf, Pill, by *Miss Roper.*

Polygonum minus Huds. In two spots on the moors between Nailsea and Kenn, S.; *C. and N. Sandwith.*

Euphorbia Cyparissias L. An old occurrence at Saltford, S., was reported by T. B. Flower (*Fl. Brist.* 525). Several plants have appeared lately in Manor Lane, near Saltford; *R. E. Taylor.*

E. platyphyllos L. Recorded by Ray as abundant near Keynsham in 1670 (*Fl. Brist.* 524). It has again appeared in neglected arable thereabout; *Miss Roper.*

Salix aurita L. On the highest ground in the Worlebury Wood, Weston-super-Mare; *H. S. Thompson.*

Cephalanthera grandiflora Gray. So few localities are known for this handsome orchid near Bristol that I was delighted to be

shown by Mr. Godwin about 20 plants flowering in Tyntesfield Park, S., with Solomon's Seal and other good woodland species.

Sparganium neglectum Beeby. Pond in a field near Yate Court, G. And in a peaty ditch on Tickenham Moor, S. ; *C. and N. Sandwith.* A long-expected addition to our flora, but so critical a species that it needed unusually keen eyes for its detection.

Wolffia arrhiza Wimm. Appears to be still spreading through the N. Somerset lowlands. In two pools by the railway near Kenn ; *C. and N. Sandwith.*

Potamogeton panormitanus Biv. Bernh. In a cattle trough on the Tyntesfield estate, Flax Bourton, S. ; *Miss Roper.*

Zannichellia pedunculata Rchb. In quantity and very characteristic in a dyke between Portbury and Portishead, S. ; *C. and N. Sandwith.*

Cyperus fuscus L. The great drought of 1921 agreed well with this rare sedge. For a short time in late August, before the rains, there was an unusually luxuriant crop in the Walton ditches. *C. longus* L. has been planted on the margin of a pond at Henbury, G., where at present it is reported by *H. J. Gibbons* to be thriving.

Eriophorum latifolium Hoppe. Boggy field at Churchill, S. ; *Miss Roper.*

Carex pulicaris L., var. *montana* Pugsley. Has been noted on Clifton Down, G. In quantity on the north shoulder of Crook's Peak, 800 ft. S.; *H. S. Thompson.* *C. divisa* Huds. A large patch near the Avon in Ashton Fields, S. First noticed by *H. J. Gibbons.* The spot had been enclosed for about ten years within a fence of the "White City," and thus protected from the riverside traffic. Before that period it is probable that the plant had been trampled into turf and prevented from flowering. It is a rather weak form, approaching the var. *chætophylla* Daveau. *C. Alden* reports this also from the Down opposite Upper Belgrave Road, where it exists under unfavourable conditions and must certainly have been introduced. *C. axillaris* Good. Roadside between Cross Hands and Iron Acton, G. ; *Miss Roper.* *C. pallescens* L. King's Wood, Yatton, S. ; *Id.* *C. depauperata* Curt. One is glad to hear that this—one of the rarest plants of the country—has been holding its own splendidly and fruiting freely in its Mendip locality. *C. riparia* Curt., var. *gracilis* Coss. and Germ. This variety was discovered on Tickenham Moor, S. in 1915 by *Miss Roper.* She writes "It was not recognized as British until recorded in the Kew Bulletin, No. 4, 1920, from Cornwall, the Isle of Wight, and the above locality."

Calamagrostis Epigeios Roth. In two spots by Berwick Wood, Hallen, G.; *C. and N. Sandwith.* Plentiful in woodland of the "Wild Country" towards Barrow Gurney, S.; *Miss Roper.*

Koeleria britannica Domin. A form with glabrous spikelets (admitted by the author). On limestone below Hotwells, Bristol, G.; *H. S. Thompson.*

Cynosurus cristatus L., f. *vivipara.* Gathered by *C. Alden* on the Downs; and in Leigh Woods by *H. J. Gibbons*—both in the autumn of 1920. A grass that is seldom seen in this condition not being on record since Miss Atwood gathered it on Clifton Down, in 1852.

Festuca arundinacea Schreb. Several good clumps on sand at Uphill, near the mouth of the Axe; *H. S. Thompson.*

Blechnum Spicant With. Two plants in Oldbury Court Woods, G., where it had not been seen for many years; *Miss Roper.*

Scolopendrium vulgare Symons, var. *latum* Lowe. Nightingale Valley, Weston-in-Gordano; *H. J. Gibbons.*

ALIENS. *Tribulus terrestris* was observed at Twerton, Bath, by S. T. Dunn in 1896. It recurred, 1920, possibly in the same spot, being recognized by the Rev. E. Ellman. *Antennaria margaritacea* R. Br. Ride amongst larches in Limeridge Wood, S.; *C. and N. Sandwith. Amsinckia* spp. Frequent about fowl-runs at Tyntesfield, S. *Hemizonia pungens*; Long Ashton, S.; *C. Bucknall. Microlonchus salmanticus,* Baptist Mills, 1911; *Herb. Roper. Onopordon illyricum* L. St. Philip's Marsh, 1904; *Id.*

In "The Garden" for July, 1920, Mr. H. S. Thompson has an instructive note on some plants still existing in the Castle Moat—an ancient waterway in the heart of the city. The more remarkable ones are the Arrowhead and Scullcap, both local plants that are not known to grow within a considerable distance of the spot.

The Lightning Discharge at Brislington Church on December 24th, 1919.

By E. H. Cook, D.Sc.

(Associate of the Royal College of Science).

FOLLOWING several rainy days, the morning of Wednesday, December 24th, was clear and bright, with a very light breeze from the South West. The afternoon became clouded and a violent storm of wind and rain of short duration burst over the district. Very few electrical discharges took place, but one of these was of extreme violence. This discharge struck the tower of Brislington Church and did considerable damage.

The barometric and thermometric readings taken in the city by Messrs. Dunscombe show a somewhat remarkable absence of variation for this time of the year. From one o'clock on Monday, the 22nd, until six a.m. on Wednesday, the 24th, the barometer had not varied one tenth of an inch. It was 29.65 inches on the Monday and 29.60 inches on the Wednesday. Then from six o'clock until 11 a.m., it rose to 29.68, and then fell to 29.60 at the period of the storm, at 3.30. From this point it remained almost perfectly level until noon on Christmas Day, when a rise began.

The thermometer was also very constant being in the neighbourhood of 45 °F. for several days. The greatest difference between the maximum and minimum thermometers being 4 °F. during the period mentioned. Therefore the temperature was remarkably steady and above the average for the time of the year.

The village of Brislington lies on the South-Eastern side of Bristol and is built in a hollow. The high ground to the North-East and South-East consisting of the Coal Measures, and on the South-West and West of the Trias. A Bench mark in the village showing only 83 feet above sea level. The Church stands above the village on the Northern side, at an elevation of about 120 feet above the sea. It is over 600 years old, built of freestone and has a tower about 80 feet high. It has never had a lightning conductor.

The electricity struck the turret pinnacle, breaking it off at its base. It then passed to the wheels and bells in the belfry immediately below, doing some slight damage to the supports and connections, and thence to a chamber below again which was filled with the wheels and other parts of the clock. Here considerable damage was done which I will describe in detail later on.

It was not so easy to trace the course of the discharge after it left the Clock Chamber. But I have no doubt that what hap-

pened was, that as it had now reached the level of the roof of the Church, it struck to the metal work on the exterior. This is shown by a crack which was made in the eastern wall of the tower where it joins on to the western end of the central aisle. Once in connection with the exterior metal work it ran right round the shuting and pipes in its mad rush to earth. No doubt some got away, but there is no evidence of damage. But when it got to the eastern end it found several down pipes along which it ran. Just at this place, however, is a row of iron railings running at right angles to the line of the church, forming the boundary of the churchyard. This railing is about 18 feet long and ends in the stone wall surrounding the premises. At the place of the entrance of the rails into the wall a large hole was blown out about 3 feet long by 18 inches wide. Here its tracks disappear.

The main bulk of the pinnacle fell through the roof of the aisle and did considerable damage. It was fortunate that no person was in the Church at the time.

Although looking very carefully, I could find no evidence of interior damage done by the lightning. It is possible, and indeed probable, that some passed along the metal fittings, but it must have been small in amount in proportion to that passing outside and it has left no trace behind.

The most interesting damage, although of course not the most serious, occurred in the Clock Chamber. This is a room of about 12 feet high, about half way up the tower and immediately below the belfry. It has a three light window on the Western side, and the wheels and pinions of the clock machinery on the Eastern side. Much of the glass was damaged and also the woodwork, but at first sight the clockwork did not appear to have suffered much injury. It had stopped, however, and on trial it was found that the wheels could not be moved. More careful examination showed that at almost every place of contact of the wheels, fusion of the metals had taken place and the parts had melted together.

It may be mentioned that this clock was started going on Christmas Eve, 1883—thirty-six years ago, by Mr. George Langford, of the Bristol Goldsmiths' Alliance, to whose kindness I am indebted for the opportunity of examining the damage, and had not stopped since.

On forcibly separating the parts and testing the steel portions, I found as I expected that almost all were magnetised, with abundant "consequent poles." These centres of magnetic force seemed to occur at any place where an irregularity in the structure of the piece of metal occurred.

In one of the corners of the room was a wooden casing, within which the weight driving the clock moved up and down. The whole of this was cracked from top to bottom and much of it scattered in splinters. Other woodwork surrounding the clock was also damaged similarly. I could not find any evidence of the bending of the leaden framework of the window, but some of the glass was blown *outwards* and some *inwards*.

I attribute all these mechanical effects to the same cause, viz., the rapid expansion of the air. During the passage of the electricity the metal conductors became highly heated. The air in contact became hot also and rapidly increased enormously in bulk, blowing out some of the glass and cracking the woodwork. In this way the pieces of glass blown outwards are accounted for. The portion which fell on the floor of the room was separated from the leaden frames by the rapid *suction inwards* after the expansion. This was caused by the rapid fall in temperature and consequently violent contraction immediately followed the discharge. In this connection it may be mentioned that Prof. John Tyndall notes a precisely similar effect, viz., that of the recoil as following a tremendous explosion which occurred at the Erith powder works, in 1864.

The fusion of the points in contact and the blowing out of the wall are due to the fact that whenever we find the passage of electricity along a conducting circuit hampered or retarded, great heat is given out at such points. Thus at the points of metallic contact there was resistance, heat was developed which fused the metals together. In the case of the railing and the wall, heat was produced at the end of the rail in the wall. This heat rapidly converted the moisture into steam and thus blew the hole in the wall.

The whole discharge is a very interesting one because of the absence of disturbing factors, and the simplicity of the results, caused by the one determining fact, viz., that the electricity took the most direct route to earth, by jumping from one mass of metal to another in order to get away to earth.

The Carboniferous Limestone (Avonian) of Broadfield Down, Somerset[1]

By F. S. Wallis, M.Sc., F.G.S.

Contents :

I. Introduction.

(a) *Previous Work.*

Broadfield Down is included in Wm. Sander's map of the Bristol Coalfields (1864) and also in the 1″ Geological Survey Map published (with additions), in 1899.

The "Memoir of the Geological Survey on East Somerset," by H. B. Woodward (1876) contains fragmentary allusions to the Carboniferous Limestone of this area, and he employs the old lithological classification.

The late Dr. A. Vaughan in his classical paper on the "Palæontological Sequence in the Carboniferous Limestone of the Bristol Area" (Q.J.G.S., 1905, p.p. 181-307), henceforth referred to as the "Bristol Paper," alludes to the area as the Backwell-Wrington Mass (ibid. p. 240) and gives the barest outline of the lithology and palæontology of the zones exposed.

1 Read before the Geological Society of London, January, 1922. See Abstract No. 1080.

The development of igneous rocks at the head of Goblin Coombe was described by Sir A. Geikie and A. Strahan in the "Summary of Progress of the Geological Survey for 1898," p. 110, by Profs. C. Lloyd Morgan and S. H. Reynolds in Q.J.G.S., Vol. LX. (1904), p. 146, and more recently by Prof. S. H. Reynolds in Q.J.G.S., Vol. LXXII. (1916), p. 23.

Thus from the standpoint of Vaughan's system of zonal notation little is known of this mass of Carboniferous Limestone, and the object of the present work is to map the outcrop of the zones and describe the lithological and palæontological sequence. The surface extent of the Avonian shown on map (Fig. II.) is mainly based on that given in the 1″ Geological Survey map, though a few slight alterations have been made. For the outcrop of the volcanic rocks of Goblin Coombe I am indebted to Prof. S. H. Reynolds, who very kindly lent me his M S. 6″ maps.

To attempt an accurate plotting of the outcrop of the Carboniferous Limestone would necessitate the digging of a large number of trial holes and the result would be extraneous to the purposes of the present paper.

Vaughan's system of zonal notation has been used throughout.

(b) *Geographical Extent.*

Broadfield Down lies a few miles S.S.W. of Bristol, the surface extent of the Carboniferous Limestone having the form of a triangle with its apex directed to the north.

On the north is the village of Backwell, westwards the Carboniferous Limestone reaches nearly to Yatton, eastwards nearly to Winford, and Wrington rests on its southern flanks. Maximum measurements give 4 miles in a N. and S. and 6½ miles in an E. and W. direction (*i.e.*, including the Yatton inlier).

The area is easily reached by road from Bristol, either by the Weston road, which skirts its north-western border, or the Bridgwater road, which lies along the eastern side of the mass.

II. General Physical and Geological Structure.

The area forms a very prominent feature in the scenery of North Somerset, rising abruptly as it does from the Yatton Moors on the west, the valley of Flax Bourton on the north and the Vale of Wrington to the south. On the east, Broadfield Down slopes gradually into Dundry Hill.

Physically the area is a plateau rising to a maximum height of 664 feet, the "broad back" of the Down (*i.e.*, North Hill) being nearer the southern than the northern boundary of the area.

Many minor undulations occur, *e.g.*, Lulsgate Bottom, a small east and west valley due to a minor syncline in the main periclinal fold. No surface streams drain the hill, though there are several dry valleys (*e.g.*, Goblin Coombe, Brockley Coombe).

Geologically the area is a greatly denuded periclinal uplift, the axis of the dome being elongated and running in a W.S.W.-E.N.E. direction through North Hill.

That peculiar marginal deposit of Triassic times—the Dolomitic Conglomerate—practically surrounds the limestone, though its development is specially noticeable on the N.W., S. and S.E. marginal slopes. It has previously been noticed by Prof. Lloyd Morgan that the outcrop of Dolomitic Conglomerate bears no relation to the present contours of the land. Thus Cheston and Bourton Coombes are comparatively recent features, whilst between them is a Pre-Triassic valley now filled with Dolomitic Conglomerate and through which the present contours are not deflected. Surrounding the Dolomitic Conglomerate is the Triassic plain of North Somerset, though much of this is now covered by alluvium.

On the eastern side much of the Carboniferous Limestone, Dolomitic Conglomerate and Trias is covered by an overlap of Rhætic and Liassic beds, and a large patch of these beds also rests on the Carboniferous Limestone in the neighbourhood of Downside.

In all probability this Carboniferous inlier was completely covered by Secondary rocks. Denudation has removed by far the greater portion of these, and has in addition greatly worn away the Carboniferous Limestone itself, the denudation of the latter being chiefly effected in Pre-Triassic times. Thus the whole of the "broad back" of the Down is composed of Z beds, and the D^2 sub-zone is not seen in the northern portion of the area. This latter fact may, however, in part be due to the covering of Dolomitic Conglomerate which throughout the area covers a variable portion of the Avonian Series and conceals the junction of the Carboniferous Limestone and Millstone Grit.

The isolation of the Yatton inlier is, I believe, due to Pre-Triassic denudation and subsequent filling of the valleys formed by Dolomitic Conglomerate, and not to faulting.

Though Pre-triassic erosion was great it did not expose the Old Red Sandstone, as was the case in each elongated pericline of the Mendips and the Bristol uplift.

III. Description of the Zones.

Zaphrentis Zone.

Surface Extent.

The zone is exposed in the neighbourhood of North Hill, Lulsgate Bottom and Pottershill. On the N.W. of its outcrop it is faulted against Heall's Scars (C zone). It is seen below the eastern volcanic exposure and forms a scar to the west of the western volcanic outcrop in Goblin Coombe.

Lithological Characters.

Thinly bedded, encrinital, mainly black dolomitised limestones. Nearly all the beds are of the "Petit Granit" type of limestone, *i.e.*, a deposit almost entirely made up of the débris of large and small crinoids. Calcite veining is very common.

clathratus Subzone (Z_1).

This is the lowest subzone exposed in the area, and is only seen at two localities (see List of Chief Exposures, p.p. 216-218). Both these places are in a small east and west depression, which fact accounts for the exposure of the subzone. Vaughan was evidently not aware of these exposures, as he states that Z_2 is the lowest subzone exposed.

Fauna.

Zaphrentis delanouei (E. & H.)	common
Syringopora θ (Vaughan)	rare
Spirifer aff. *clathratus* (M'Coy) emend. Vaughan	very common
Orthotetes crenistria (Phil.) mut Z (Vaughan)	,,
Productus cf. *martini* Sow.	common
Pustula pustulosa (Phil.)	,,
Leptæna analoga (Phil.)	,,
Chonetes cf. *hardrensis* (Phil.)	,,
Euomphalus sp.	rare

konincki Subzone (Z_2).

Exposed chiefly at Lulsgate Bottom, Pottershill and Goblin Coombe.

Fauna.

Zaphrentis konincki (E. & H.)	common at top
Zaphrentis omaliusi (E. & H.)	common
Caninia cylindrica (Scouler) mut γ (Vaughan)	very common at top

Caninia cornucopiæ Mich.	rare
Syringopora θ (Vaughan)	,,
Amplexus cf. *coralloides* (Sow.)	,,
Orthotetes crenistria (Phil.) mut Z (Vaughan)	very common
Syringothyris cuspidata mut *crytorhyncha* (North)	,,
Cliothyris glabistria (Phil.)	,,
Tylothyris laminosa (M'Coy) emended North mut γ (North)	,,
Chonetes papilionacea (Phil.)	common

HORIZON γ, chiefly exposed at an Old Quarry E. of Heall's Scars and in Goblin Coombe, is characterised by the great abundance and co-occurrence of *Caninia* and *Zaphrentis*, in addition to the brachiopods mentioned as occurring in Z_2.

Syringothyris ZONE.

SURFACE EXTENT.

The zone forms a belt of varying width round the Z zone, the continuity being broken on the east by the Liassic overlap. It is the dominant zone in the formation of Goblin Coombe and Heall's Scars and forms the whole of Wrington Warren.

LITHOLOGICAL CHARACTER.

In descending order :—

(3) Massive fossiliferous grey limestones, sometimes oolitic with subsidiary "china-stones." A red ferruginous staining is often seen on the surface of a freshly broken specimen of "china-stone" from this zone.

(2) A thick band of oolitic limestone (Caninia Oolite). The diameter of the ooliths varies in different parts of the sequence. The basement beds are always composed of a white rock with very large grains, the ooliths being much smaller in the upper beds. One band is generally deeply stained with iron, giving rise to a red oolitic bed, which always contains *Productus cora. mut. C.* in great abundance and occurs to the east of the western fault in Goblin Coombe, and is also seen in several quarries near Butcombe Court.

(1) Thick beds of yellow dolomitic limestone (Laminosa Dolomites) with a few subsidiary shaly bands. These latter bands always give rise to gentle grass-covered slopes which are in marked contrast to the Caninia Oolite scarps, e.g., in Goblin Coombe and Heall's Scars.

FAUNA.

Syringopora cf. *reticulata* Goldf.	very common
Cyathophyllum φ (Vaughan)	,,
Caninia cylindrica (Scouler) mut S, (Vaughan)	common at top
Orthotetes crenistria (Phil.) mut C (Vaughan)	common
Chonetes aff. *papilionacea* (Phil.)	,,
Chonetes cf. *comoides* (Sow.)	,,
Syringothyris cuspidata mut *exoleta* (North)	,,
Productus aff. *cora* (D'Orb.) mut C (Vaughan)	,,
Tylothyris laminosa mut γ (North)	rare, but characteristic
Cliothyris glabistria (Phil.)	rare
Bellerophon sp.	abundant at certain levels
Euomphalus sp.	,,

Seminula ZONE.

SURFACE EXTENT.

This zone forms the major part of the periphery of the visible extent of the Avonian of Broadfield Down. The width of the outcrop is very inconsistent, chiefly because of the variable amount of denudation of the zone and of the extent of overlap of the Dolomitic Conglomerate.

Dial Quarry, Bourton Coombe, Cheston Coombe, Brockley Coombe, Goblin Coombe and a large portion of the Yatton Inlier are formed of Seminula beds.

The large extent of this zone in the area to the S.W. of Goblin Coombe is probably due to strike faults. No good exposures are available in this area, but frequent traverses of the district point to this conclusion, as from the examination of stones thrown out by rabbits, &c., the thickness of the Seminula Oolite would be very abnormal unless strike faulting were present. The other possibility of extensive undulations in the strata was considered, but no beds other than that of Seminula Oolite were found. In support of this hypothesis of strike faulting, it may be noted that in the quarry at the entrance to Cheston Coombe a fault in the Seminula Oolite is clearly visible.

semireticulatus SUBZONE (S_1).

LITHOLOGICAL CHARACTER.

Massive thinly bedded limestones with a few thin shaly partings. "China-stones" are prominent and many of the lime-stones are dolomitised. In the upper beds the limestone is hard and black, more thickly bedded, and contains a band of pale pink lenticular chert.

Owing to its variable lithic properties this subzone is not much quarried and hence little exposed.

FAUNA.

Caninia cylindrica (Scouler) mut S_1 (Vaughan)	rare
Syringopora cf. *distans* (Fischer)	common
Carcinophyllum mendipense (Sibly)	,,
Lithostrotion martini (E. & H.)	enters at base and is the dominant coral throughout.
Seminula ficoidea (Vaughan)	increases in abundance towards top.
Productus θ (Vaughan)	very common
Chonetes papilionacea (Phil.)	,,
Productus semireticulatus (Martin)	rare
Euomphalus sp.	,,
Orthoceras (*Poterioceras*) sp.	,,

Caninia cylindrica mut S_1 is only found at the base of the subzone. In Dial Quarry, which only includes the topmost beds of S_1, Vaughan (" Bristol paper " p. 241) queries its occurrence. Careful search has produced in negative results.

At the top of the subzone is a band of limestone only 4—5 inches thick, containing a rich faunal assemblage. The band is here termed the " Fossiliferous Level," and as it is recognisable in many parts of the area it forms a very convenient dividing line, in the field, between S_1 and S_2. The fauna of this level is as follows :—

Lithostrotion martini (E. & H.)
Syringopora cf. distans (Fischer)
Syringopora cf. ramulosa, Goldf.
Productus cora (D'Orb.), mut S_2 (Vaughan)
Productus aff. hemisphericus Sow.)
Seminula ficoidea (Vaughan)
Athyris cf. expansa (Phil.)
Pustula elegans (M'Coy)
Pustula punctata (Martin)

cora SUBZONE (S_2).

SURFACE EXTENT.

Owing to extensive quarrying, this subzone is well exposed and is specially well seen at Dial Quarry, the quarries at the entrances to Cheston Coombe, Bourton Coombe, and Goblin Coombe, the large quarry in the Yatton inlier and near Udley.

LITHOLOGICAL CHARACTER.

Chiefly massive thickly bedded limestones. The lower part includes three bands of pale pink nodular and lenticular chert interbedded in the limestone. Above this is the Seminula Oolite, followed by a series of "china-stones." At the top is a well-developed Modiola Phase consisting of Concretionary Beds (interbedded with shales), Seminula Pistolites, contemporaneously brecciated limestones and calcite mudstones.

In the majority of the exposures the rocks are veined with calcitic, quartzite and ferruginous (chiefly hæmatite) deposits. The strata of this level are often much disturbed.

FAUNA.

Lithostrotion martini (E. & H.)	very common
,, *affine* Flem.	rare
Syringopora cf. distans (Fischer)	common
,, *cf. geniculata* (Phil.)	rare
Carcinophyllum θ (Vaughan)	,,
Lithostrotion basaltiforme (Phil.)	,,
Cyathophyllum murchisoni (E. & H.)	,,
Alveolites septosa (Flem.)	,,
Seminula ficoidea (Vaughan)	very common
Productus cora (D'Orb.) mut S_2 (Vaughan)	common
Productus aff. *hemisphericus* Sow.	,,
Chonetes papilionacea (Phil.)	,,
Productus giganteus (Martin)	in upper beds only
Chonetes aff. *comoides* (J. Sow.)	rare
Orthotetes crenistria (Phil.)	,,
Cyrtina carbonaria (M'Coy)	rare and only in lowest beds

Dibunophyllum ZONE.

SURFACE EXTENT.

The area occupied by this zone is very limited, partly because of enormous denudation and partly because of its concealment by Dolomitic Conglomerate and other Triassic deposits. Small patches occur at Hartcliff Rocks, the Yatton Inlier, North of Wrington, W. of Udley, near Winford Manor and S. of Butcombe Court.

LITHOLOGICAL CHARACTER.

Massive limestones, sometimes oolitic and sometimes iron-stained, with subsidiary shaly partings. Corals occur in the limestone bands and brachiopods in the shaly partings.

θ φ Sub-Zone (D1).

Cyathophyllum murchisoni (E. & H.)	very common
Alveolites septosa (Flem.)	,,
Dibunophyllum θ (Vaughan)	common
Dibunophyllum φ (Vaughan)	,,
Syringopora cf. *distans* (Fischer)	,,
Syringopora cf. *geniculata* (Phil.)	,,
Productus giganteus (Mart.)	very common
Productus hemisphericus, Sow.	,,

Lonsdalia Subzone (D2).

This subzone is best exposed in the Wrington Quarries.

Fauna.

Alveolites septosa (Flem.)	common
Syringopora cf. *distans* (Fischer)	,,
Cyathophyllum murchisoni (E. & H.)	,,
Lonsdalia floriformis (Flem.)	,,
Dibunophyllum ψ (Vaughan)	,,
Axophyllum θ (Vaughan)	,,
Lithostrotion portlocki (E. & H.)	rare
,, *ensifer* (E. & H.)	,,
,, *irregulare* (Phil.)	very common
Productus giganteus (Martin)	common
Productus hemisphericus Sow.	,,
Productus latissumus, Sow.	rare
Crinoids.	common
Fenestella sp.	,,

IV. (a) Description of the Best Exposures.

In order to avoid undue repetition in the following descriptions, mention will only be made of points of special interest, it being understood that in other details the section follows the general lithological and palæontological details given in III.

1. Dial Quarry (Dod's Quarry of Vaughan, "Bristol Paper," p. 241) is situated on the N.E. flank of the area, and is about one mile due south of Barrow Gurney. It shows by far the best section in the area, the top of S1 and the whole of S2 being splendidly exposed (see Fig. No. III).

The chert bands of top S1 and base S2 are well seen in the S.W. part of quarry, the Seminula Oolite occupies the middle portion and the "Concretionary Beds" with associated "china-stones" and shales are well seen in the N.E. corner. The rocks are very little disturbed, and the hæmatite deposits, so characteristic of the S2 of Broadfield Down, are absent.

The small fragments of *Cyrtina carbonaria* were found here, which fixed the division line between S_1 and S_2 as immediately above the "Fossiliferous level." The "Fossiliferous level" was first detected in this quarry, and afterwards found in many other parts of the area.

2. HARTCLIFF ROCKS form a small interesting section about 500 yards S.E. of Dial Quarry, and includes upper S_2 and lower D_1. The beds are much disturbed and extensively veined with calcite and hæmatite. In the majority of cases the hæmatite (rarely limonite) occurs as a vein deposit in cracks and fissures in the limestone, with a sharp line of demarcation between it and the country rock. Sometimes calcite occupies the centre of the vein and hæmatite the marginal portions, whereas in other cases quartz nearly fills the middle portion, the final stage being a thin deposit of hæmatite in the middle of the quartz. Veins with quartz only occur immediately underlying the pocket of Dolomitic Conglomerate, and as chert nodules have been found in this latter deposit, in all probability the silica came from that source. All veins coalesce upwards, and both the calcite and quartz crystals (forming the gangue) have their long axes at right angles to the direction of the vein. In a few cases, the hæmatite appears to be a bedded metasomatic replacement of the limestone. Here the junction with the country rock is very indefinite.

Another interesting deposit is the pocket of Dolomitic Conglomerate, consisting of blocks of Carboniferous Limestone (fossiliferous and of S_2 and D_1 age). Some of the fragments are rounded, elsewhere the deposit is more in the nature of a breccia. The matrix is scanty. No fault can be traced to account for the position of this deposit, and it appears to fill a solution valley in the Carboniferous Limestone, possibly made by a small Pre-Triassic dip-stream flowing North.

Rock's Wood to the east contains abundant fossil evidence of D_1. The extent of this tongue of limestone has been slightly modified from the Survey mapping.

3. BOURTON COOMBE. The Quarry at the entrance to the Coombe (about 450 yards S. of Flax Bourton) shows a typical Broadfield Down development of S_2—massive limestones with extensive calcite and hæmatite-veining, capped by a marked development of the S_2 Modiola Phase.

The whole of the Coombe lies in S_2 beds. In the lower half it cuts across the strike, whilst the strike is followed in the upper half. The wall (shown on 6″ map) marks the end of the Coombe proper and the beginning of a much broader valley in S_1. The cherts and silicified *Lithostrotions* of lower S_2 are well seen, and the "Fossiliferous level" can easily be detected.

The Coombe, in common with similar Coombes in this area, is in a bad state for geological observations, moss, fungi, etc., covering the rocks.

4. CHESTON COOMBE, BACKWELL. This is very similar to Bourton Coombe. The quarry at the entrance to the Coombe shows a portion of S_2. The "Concretionary Beds" are present, though the usual calcitic and hæmatitic deposits are absent. The whole of the Coombe is in S_2 beds. The "Fossiliferous level" is well seen in a small quarry near Jubilee Stone at the head of the Coombe.

5. BROCKLEY COOMBE. The whole of this Coombe lies in the S. zone. It is divided into three sections by two right angle bends, and geologically it may be described in these three parts.

In the first section (near the Bristol road) the Coombe is at right angles to the strike. In the middle third it runs parallel to the strike, the high scarp face on the N.W. being formed of Seminula Oolite. In the last third the direction of the Coombe varies, sometimes being parallel to and sometimes crossing the strike at an oblique angle.

The "Fossiliferous Level" has not been detected here, and hence the exact line of division between S_1 and S_2 is uncertain.

6. GOBLIN COOMBE.—The quarry opposite the school at the entrance to the Coombe is in massive S_2 beds and shows a good development of the "Concretionary Beds."

The lower portion of the Coombe up to the N. and S. wall (shown on 6″ map) cuts the strike obliquely, and hence lower horizons are seen as the Coombe is ascended. Cleeve Toot is formed of S_2 beds, its prominence being due to bands of chert, interbedded with the limestones. On the northern slope of the Coombe, East of the wall, are two scarps, the higher one formed of C_2, the lower of Caninia Oolite (C_1). Immediately below the latter scarp is a grassy slope formed of the Laminosa Dolomites, this being followed by another steeper scarp of γ beds. Both *Caninia* and *Zaphrentis* are extremely abundant in these latter beds.

The next scarp face is formed of Caninia Oolite, and hence a fault must occur between these two scarps. The strike now changes to nearly N. and S., though it soon swings back to the old W.S.W.–E.N.E. direction. These changes in strike are accompanied by similar variations in the direction of the Coombe.

On the W. side of the second wall is a grassy slope formed of Laminosa Dolomites, whilst on the E. side is the first of the volcanic exposures. Immediately following the volcanic rocks is a small

tract devoid of exposures, the next scarp face being formed of Caninia Oolite. This is followed by the usual grassy slope of Laminosa Dolomites, and then the γ beds which are brought to the surface by a reversed fault, the fault giving the explanation of the absence of volcanic beds at this junction. The eastern volcanic development appears in normal sequence, another reversed fault cutting out the basalt in the area to S.E. of Warren House (see Fig. 4b), where it should normally occur.

Thus the Caninia Oolite plays a large and important part in the formation of Goblin Coombe, whereas the courses of Brockley, Cheston, and Bourton Coombes are determined by rocks of the S zone.

7. YATTON INLIER. A large quarry on the N.W. flank shows in the lower part a splendid section of the S_2 Modiola Phase. Concretionary Beds, Seminula Pisolites, contemporaneously brecciated limestones and calcite mudstones are all well developed. The upper part shows a development of iron stained D_1 limestones, brought in by a small strike fault. The extension of this fault is unknown, as careful search for D beds on the opposite side of Cadbury Hill produced negative results.

8. UDLEY QUARRY, situated about 1 mile N.W. of Wrington, shows a section in upper S_2. The apparent thinning of the beds on the western side of the quarry is due to the weathering of a Pre-Triassic valley. The valley was subsequently filled with Dolomitic Conglomerate, which now rests with marked unconformity on the Carboniferous rocks.

The rocks are very fossiliferous, the rare occurrence of *Alveolites septosa* and *Cyathophyllum murchisoni* in beds of Seminula age, being recorded from this quarry.

9. WRINGTON QUARRIES. These well known quarries have been so fully described by Vaughan in his "Bristol Paper," p. 242, and by Professor Reynolds in his "Excursion Handbook for the Bristol District," Ed. 11, p. 72, that the mere mention of them will suffice here. They still form a good collecting ground for D_2 corals, and are interesting as the only D_2 exposures on Broadfield Down.

(b) LIST OF CHIEF EXPOSURES.

Only exposures in a fair condition for examination are included here, small exposures in hedges, etc., being omitted. The reference is to the 6″ O.S. maps of Somerset.

Zaphrentis ZONE.

Old Quarry in field N. of Oatfield Farm ..	Hor. γ	11 N.E.
Old Quarry, Pottershill	Z_2	11 N.E.
Quarry N.E. of Church, Lulsgate Bottom	Z_2	11 N.E.
Quarry, Lulsgate Bottom	Z_2	11 N.E.
Quarry, half-mile S.W. Lulsgate Bottom	Z_1	11 N.E.
Quarry S. of Warren House	Z_1	11 N.E.
Scarp 350 yards S.W. of Warren House ..	Hor. γ	11 N.W.
Exposures at top of Goblin Coombe ..	Z_2 & Hor. γ	11 N.W.

Syringothyris ZONE.

Quarry S. of main road, 450 yds. S.W. Dial Quarry	C_1	11 N.E.
Old Quarry S. of main road, 350 yds. S.W. Dial Quarry	C_2	11 N.E.
Old Quarry N. of main road, 600 yds. S.W. Dial Quarry	C_1	11 N.E.
Old Quarry, 800 yds. W. of Dial Quarry ..	C_1	11 N.E.
Old Quarry N.E. of Freeman's Farm, Barrow Hill	C_1	11 N.E.
Heall's Scars	C_1 & C_2	11 N.E.
Small exposure N. of Hyatt's Wood, Backwell Hill	C_2	5 N.E.
Old Quarry, 500 yds. N. of Warren House	C_1	11 N.W.
Old Quarry, nr. Pot's Hole, Brockley Coombe	C_1	11 N.W.
Several scars S. and S.W. of Warren House, Goblin Coombe	C_1	11 N.W.
Scar on N. side of Goblin Coombe, astride N. and S. wall	C_2	11 N.W.
Small exposures S. of Broadfield Farm ..	C_1	11 N.E.
Quarry, 550 yds. N.W. of Butcombe Court	C_1	11 S.E.

Seminula ZONE.

Dial Quarry (1 mile S. of Barrow Gurney)	S_1 (top) & S_2	11 N.E.
Hartclift Rocks, S.E. of Dial Quarry ..	S_2 & D_1	11 N.E.
Old Quarry, N. of main road, 350 yds. S.W. of Dial Quarry	S_2	11 N.E.
Old Quarry, 650 yds. W.N.W. of Dial Quarry	S_1	11 N.E.
Old Quarry, Naish Lane	S_2	11 N.E.
Bourton Coombe, Flax Bourton ..	S_1 & S_2	5 S.E.
Quarry, 200 yds. E. of Old Quarry, Barrow Hill	S_1 (top)	5 S.E.
Old Quarry, S.E. of Backwell	S_2 (top)	5 S.E.
Cheston Coombe, S.E. of Backwell ..	S_1 & S_2	5 S.E.
Small Coombe, S. of Cheston Coombe (with Water Co. supply pipes)	S_1 & S_2	5 S.E.

Quarries, 950 yds. E. of West Town ..	S_2 (top)	5 S.W.
Quarries, N.E. of Tap's Coombe	S_2	11 N.W.
Brockley Coombe to B.M. 302.9	S_1 & S_2	11 N.W.
Old Quarries, N.W. of Cleeve Hill ..	S_2	11 N.E.
Quarries at entrance to Goblin Coombe ..	S_2	11 N.W.
Cleeve Toot and lower portion of Goblin Coombe	S_1 & S_2	11 N.W.
Old Quarry, S.W. of Wrington Hill ..	S_1 (top)	11 N.W.
Old Quarries E. and W. of Rhodyate Hill	S_2	11 N.W.
Quarry E. of Cadbury Hill	S_2	11 N.W.
Old Quarry, 300 yds. S.E. of Rhodyate House	S_2 & D_1	11 N.W.
Old Quarries, S. of Cadbury Hill	S_2	10 N.E.
Frost Hill Quarry, S.E. of Yatton ..	S_2	10 N.E.
Quarry, N. of Cadbury Hill	S_2 & D_1	10 N.E.
Old Quarry, 400 yds. W. of Prospect Farm	S_2	11 S.W.
Quarry, N.W. of Udley, nr. Wrington ..	S_2 (top)	11 S.W.
Old Quarries nr. Meeting House Farm, $1\frac{1}{8}$ miles N.E. of Wrington	S_2	11 S.W.
Quarry, 800 yds. N.E. of church, Redhill	S	11 S.E.
Quarry, 200 yds. N.E. of church, Redhill	S_2 (top)	11 S.E.
Quarry, 700 yds. S.E. of Butcombe Court	S_2 & D_1	11 S.E.
Quarry, S.E. of Winford Manor	S_2 & D_1	11 N.E.
Quarry, N.E. of Winford Manor	S_2 & D_1	11 N.E.
Quarry, 300 yds. S. of Kingdown ..	S_2	11 N.E.
Quarry at Kingdown	S_1 (top)	11 N.E.

Dibunophyllum Zone.

Quarries S. of Row of Ashes Farm, near Butcombe Court	D_1	11 S.E.
Quarries N. of Wrington	D_2	11 S.W.

All exposures showing both S and D beds are included under the Seminula Zone.

V. Comparison of the Avonian of the Broadfield Down Area with that of the Bristol and Mendip Areas.

As might be supposed from the geographical position of Broadfield Down—approximately midway between the Bristol and Mendip area—both its lithological and palæontological characteristics are intermediate between the developments of the two named areas. The description given in 111 amply proves this, and it is noticed that sometimes the development of Broadfield Down leans towards that of the northern facies and at other times

towards that of the southern facies. The following references (in addition to the "Bristol Paper") were consulted in making this comparison :—

"Carboniferous Limestone of Mendip area." Dr. T. F. Sibly, Q.J.G.S., 1906, here referred to as the "Mendip Paper."

"Avonian of Burrington Coombe." Dr. A. Vaughan and Prof. S. H. Reynolds, Q.J.G.S., 1911, here referred to as the "Burrington Paper."

Zaphrentis ZONE.

Over the whole of the Bristol District the exposures of this zone are very similar both in their lithology and palæontology. Broadfield Down proves no exception to this similarity.

The area strongly leans to the southern facies in its strong definition of horizon γ, *i.e.*, beds characterised by great abundance and co-occurrence of *Caninia* and *Zaphrentis*.

Although chert occurs both in the Bristol and Mendip areas, it has not yet been exposed (or is absent) on Broadfield Down.

In the abundance of *Tylothyris laminosa mut* γ at the top of Z_2 a close resemblance is shown to the Mendip facies, as this fossil does not reach its maximum until lower C_1 in the Bristol area.

Syringothyris ZONE.

In the lower part of this zone, the development of the Laminosa Dolomites and Caninia Oolite shows a similar type of sedimentation to that of the Avon Section, though the thickness of the Caninia Oolite is much greater.

The upper part of the zone leans more to the southern facies, consisting as it does of massive fossiliferous grey limestones, sometimes oolitic and with subsidiary "china-stones."

It has been clearly shown ("Bristol Paper," p. 185, and "Mendip Paper," p. 357) that there is a relative acceleration of certain coral-groups on the brachiopod progression as we pass from north to south in the Bristol District. A detailed study of the coral fauna of Broadfield Down supplies another link in the chain of evidence. This *Caninia cylindrica* mut S_1 attains a maximum in C_2 of the Mendip area, in the topmost beds of C_2 in Broadfield Down, and not until S_1 in the Bristol area.

Seminula ZONE.

semireticulatus SUBZONE.

In this subzone the development is similar to that of the Bristol area, though as yet no trace of algal action in the lime-

stones has been discovered. The occurrence of chert in the uppermost beds is similar to its occurrence in the Mendip area.

The occurrence of *Pustula elegans* in the " Fossiliferous level " (see p. 211) is interesting, as hitherto its first recorded appearance in the eastern part of the South-west Province was in the D_2 subzone of Mendip Area (Mendip Paper, p. 335). It has, however, been found in C_2 or S_1, Lydstep Point, Pembrokeshire, base S_1 (?) Giltar Point, Pembrokeshire, and S_1 of Co. Clare, Ireland.

Similar well-marked faunal bands of no great vertical thickness have been recorded (Q.J.G.S., 1906, p. 367, and Q.J.G.S., 1905, p. 560) from both lower and upper S_1 of Cheddar and Weston. The band in upper S_1 has *Productus* aff. *hemisphericus, Athyris* cf. *expansa,* and *Lithostrotion martini* in common with the fossils found in the Broadfield Down " Fossiliferous Level."

In Dial Quarry *Cyrtina carbonaria* has been found immediately above the " Fossiliferous Level," and hence in field work, as *Cyrtina carbonaria* is extremely rare, the " Level " is taken as the dividing line between S_1 and S_2.

The occurrence of *Athyris* cf. *expansa* and *Carcinophyllum mendipense* is a link with the Mendip facies, as the former is only rarely known from D_1 of the Avon Section, while the latter has not been recorded in the Bristol Area.

cora Subzone.

Here the lithological and palæontological sequence is similar to that of the Avon Section, except that no band of Seminula Pisolite has been recognised at the base of the subzone. The Modiola Phase at the top is well marked.

The abundance of *Productus giganteus* and *Productus* aff. *hemisphericus* at the top of this subzone is very marked in Broadfield Down, and is perhaps more characteristic of the Mendip than of the Bristol Area.

Dibunophyllum Zone.

θ φ Subzone.

Lithologically and palæontologically this subzone is very similar throughout the whole of the Bristol District. The red ferruginous staining so notable in the Avon section may or may not occur in Broadfield Down, and does not occur in the Burrington Section.

Lonsdalia Subzone.

This subzone is only exposed in the Wrington District, where it has a very similar facies to that exposed in the Avon Section. The subzone is only exposed in very limited areas in the Mendips.

VI. Conclusion.

The chief points of interest may be summarised as follows:—

1. The area affords yet another proof of the application of Vaughan's zonal classification of the Carboniferous Limestone to areas other than the type of the Avon Gorge, Clifton.

2. Both lithologically and palæontologically the area holds an intermediate position between the developments of the Bristol area and Mendip area.

3. A well-marked faunal band ("Fossiliferous Level") occurs in S_1 and constitutes in this area a useful field determination of the dividing line between S_1 and S_2.

4. *Pustula elegans* (M'Coy) is here recorded from the S_1 subzone.

5. Subzones Z_1 and D_1 hitherto unrecorded, have been proved to be exposed in this area.

In May, 1921, the Council of the Geological Society of London awarded me the "Daniel-Pidgeon Fund." I take this opportunity of tendering to them my sincere thanks not only for the monetary help towards the expenses, but also for the great encouragement to further research which such an award carried with it.

In conclusion I should like to tender my sincere thanks to Mr. H. Bolton, M.Sc., and Professor S. H. Reynolds, M.A., Sc.D.; to the former for his technical advice with maps, &c., to the latter for the great willingness he has always shown in discussing the area with me, and his continual help in all matters relating to Carboniferous Limestone stratigraphy. To both I am indebted for much encouragement and advice through what has meant a considerable amount of field work over a large area.

I must also thank Messrs. D. E. I. Innes, M.A., and V. A. Eyles, B.Sc., for several days' helpful companionship in the field. Part of the cost of publishing this research has been defrayed by a grant from the University of Bristol Colston Society.

SKETCH MAP

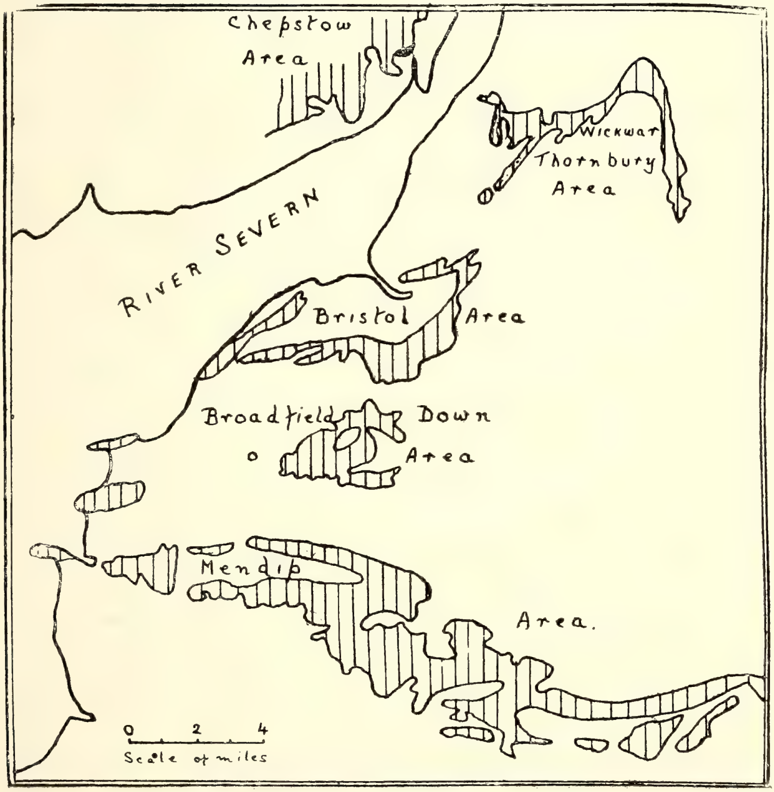
of the surface extent of the

CARBONIFEROUS LIMESTONE

(shaded) of the

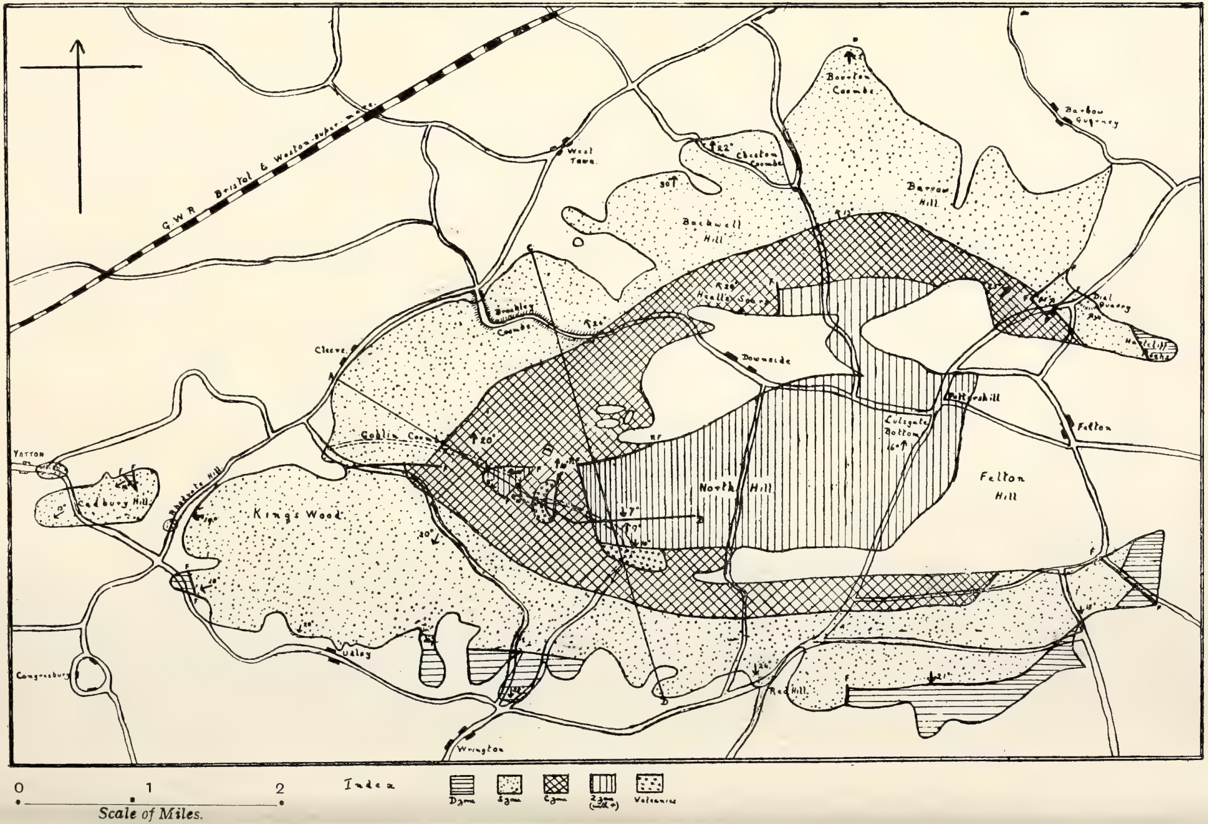
BRISTOL DISTRICT.

FIG. 1.



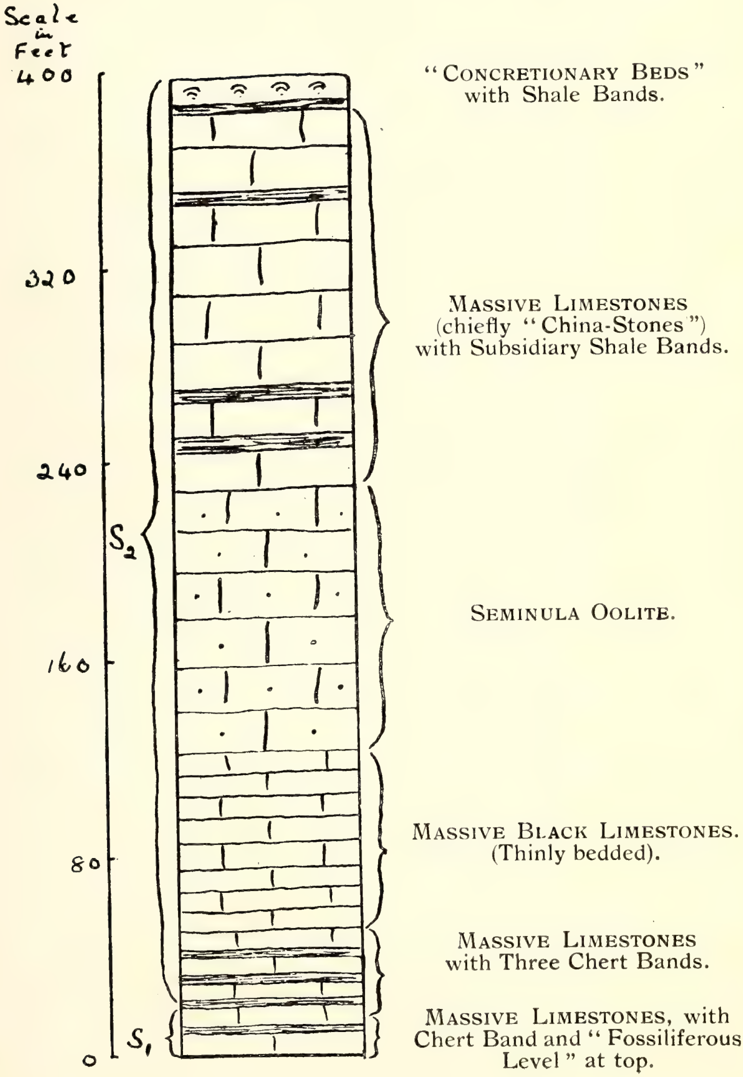
ZONAL DISTRIBUTION MAP OF BROADFIELD DOWN.

FIG. 2.



VERTICAL SECTION
OF
DIAL QUARRY.

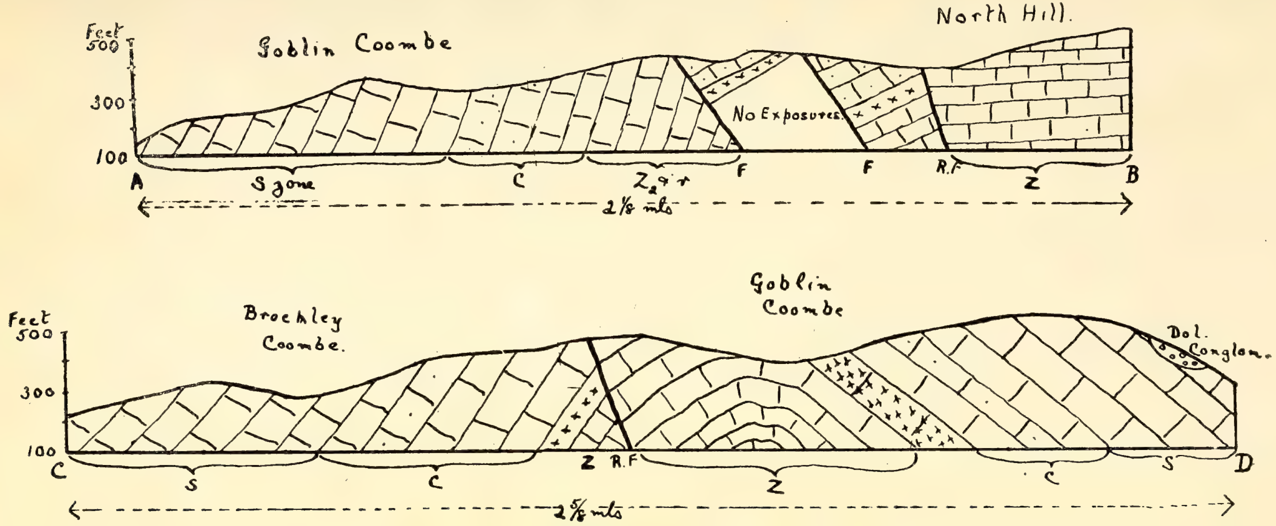
FIG. 3.



Vertical Scale 1" = 80 ft.

Horizontal Sections along lines A-B and C-D on Fig. 2.

FIG. 4.



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To December 31st, 1922.

THE success of the Society has continued to be satisfactory in a quiet way, and that the work it seeks to make popular amongst the scientific-minded citizens has a recognised value is shown by the Lord Mayor of Bristol giving an official Reception, to include our Society as special guests amongst other scientific workers. To entertain his guests we organised with the Bristol Field Club and the Bristol Microscopical Society an Exhibition of Natural History objects on a large scale, and it can be said without hesitation, that this effort proved how numerous are the specimens that can be brought quickly together to illustrate various groups of living or dead organisms, and how wide an interest exists amongst our members to obtain some knowledge of Nature's mysteries.

At the same time the number of people who are willing to join an old-established Society like ours for the purpose of encouraging each other does not seem to increase. During the year we have only elected twelve new members, which just balances the loss by death and removals that are sure to occur. The membership is 143, including 17 Associates under the old election.

The year began with a new President, Mr. H. Womersley, who with his knowledge of Entomological subjects has brought about continued activity amongst those workers who have done so much for that Section during the past two years.

Study in a different direction has resulted in the formation, at the end of the year, of a new Section of the Society devoted to Ornithology, and best wishes for its success are offered to Mr. Coldstream Tuckett, whose enthusiasm and labours have brought it to a promising beginning.

During the year our President has devoted much thought and time to organising a Union of South-Western Naturalists. Prof. C. Lloyd Morgan has become its first President, and several of our members, with the sanction of Council, have joined the Executive. It remains for individual members to join its ranks at the moderate subscription payable by those who already belong to our Society, and to support its efforts to link up the work of the Naturalists scattered over the neighbouring counties.

A fortunate opportunity arose for the Library of the Society to be deposited at the Museum and Art Gallery, and Council took advantage of it to renew an old association, and to gain advantages for the better use of the valuable collection of books.

The four Excursions took place in the summer months, but for various reasons the attendance was smaller than in past years, notwithstanding the attractions of the localities and the pleasant conditions that accompanied them.

We have to recall with regret the death of Mr. H. F. Jolly, an active member of the Council, and of Mr. J. C. Blackmore, F.G.S., who joined the Society fifty-eight years ago, and has at all times taken a warm interest in its welfare.

IDA M. ROPER,

Hon. Secretary.

The HON. TREASURER in Account with the BRISTOL NATURALISTS' SOCIETY.

DR. GENERAL ACCOUNT FOR THE YEAR 1922. CR.

	£	s.	d.
To Members' Subscriptions—			
Ordinary	34	5	0
Associate	4	0	0
Life Membership	5	0	0
,, Entrance Fees	1	15	0
,, Subscriptions in advance	3	10	0
,, Arrears collected	6	0	0
,, Donations	5	0	0
,, Sale of " Proceedings," etc.	1	1	5
,, Balance forward	105	14	0
,, Donations to Book-binding Fund ...		10	0
	£166	15	5

	£	s.	d.
By Subscriptions to Societies—			
Ray	1	1	0
Commons and Footpaths		10	6
,, Cost of " Proceedings," 1920 and 1921 ...	47	12	6
,, Printing	5	2	6
,, Fire Insurance		7	6
,, Rent of Library and Rooms	4	11	0
,, Postages	5	0	2
,, Gratuities	1	0	0
Removal of Library Fittings	3	11	0
,, Books Bought	14	18	9
,, Cash in hand	75	18	3
,, Bookbinding	7	2	3
	£166	15	5

Audited and found correct.

ERNEST H. COOK
CHARLES BARTLETT, A.C.A. } Auditors.

Librarians' Report.

For the Year 1922.

IN previous Reports the lack of space for the display of the books in the Library has been mentioned, and as notification was received early in the year that the rent of the room in use in Berkeley Square would be raised, negociations were opened with the Committee and Director of the Bristol Museum and Art Gallery to provide better accommodation.

The happy result was that the Society was able to deposit its Library of about 3,000 bound volumes and numerous unbound ones, during the month of June, on the shelves of an excellent room at the Museum, and once more enter into a close relationship with the Natural History collections of the City.

Members have expressed great satisfaction at the orderly arrangement of the books under the different subjects as well as at their appearance in the new surroundings, and the comfort in which they can be consulted. An increased use of the books has resulted, and the number of borrowers has become more numerous.

Another sign of the increased interest in the Library generally is shown by the gifts of books from various members, in some instances to fill gaps in the long series of valuable publications accumulated on the shelves. Further gifts will be acceptable, especially of modern date.

The book-binding fund is exhausted, and as there are still a great number of recent publications of scientific corresponding societies which cannot be placed on the shelves we feel this is a serious restriction to the use of the most recent works.

The following gifts have been received, and thanks are given to the donors for them :—

" Somerset Archaeol. and Nat. Hist. Soc. Proceedings," 1912-1921, from Mr. T. Charbonnier.

" Hortus Mortolensis," 1912.

" Waterton's Essays on Natural History," 2 vols., 1846. and

" The Woodlands of England " (pamphlet), from Mr. H. S. Thompson, F.L.S.

Tristram, " The Natural History of the Bible," 1911, from Mr. W. Griffiths.

Gray, " The Entomology of Australia," Pt. I., 1833, from Mr. J. W. Tutcher.

Birchley, " British Birds," 2 vols., 1909, from Mr. C. Tuckett.

" Review of Applied Entomology," 1917-1920, from Messrs. Christopher Thomas & Bros., Ltd.

Lowe, " Ferns, British and Exotic," 8 vols., 1872.

" Newman's Phytologist," 5 vols., 1844-54.

" Dictionary of Husbandry," 2 vols., 1779. and

" Journals and Proceedings of the Linnean Society," to date, from Mr J. W. White, F.L.S.

" British Science Guild Report," 1922, from Mr. G. C. Griffiths, F.E.S.

" Peculiar form of *Hygromia fusca* from Leigh Woods " (pamphlet), from the author, Mr. A. D. R. Bacchus, F.E.S.

Smith, " Handbook of British Lichens," 1921. and

Two Economic Guides on " The Cockroach," and " Mites Injurious to Domestic Animals," from the Trustees of the British Museum.

" Paleontographical Society," vol. 73, 1919, and vol. 74, 1920, from the Geological Section.

By subscription we have received :—

" Zoological Record," vol. 57, 1920.

" Taylor's Mollusca of the British Isles," pt. 24.

The Ray Society, " British Marine Annelids," vol. IV., by Prof. McIntosh.

ARTHUR B. PROWSE, Lieut.-Col. R.A.M.C.,
Hon. Librarian.

IDA M. ROPER, F.L.S., *Hon. Sub-Librarian.*

Exchange List.

Ashmolean Natural History Society of Oxfordshire
Barrow Naturalists' Field Club
Belfast Naturalists' Field Club
Birmingham Natural History and Philosophical Society
Bristol Museum and Art Gallery
——— University of, Speleological Society
British Association
——— Museum (Natural History), S.W.
Cardiff Naturalists' Society
Chester Natural Science Society
Cornwall, Royal Geological Society of
————, Royal Institution of
————, Royal Polytechnic Society
Cotteswold Naturalists' Field Club
Croydon Natural History and Scientific Society
Ealing Scientific and Microscopical Society
Edinburgh Geological Society
————— Royal Botanic Society
Essex Field Club
Geological Society of London
———— Survey and Museum, London
Geologists' Association
Glasgow, Geological Society of
———— Natural History Society of
———— Philosophical Society
Hertfordshire Natural History Society and Field Club
Liverpool Geological Society
———— Literary and Philosophical Society
———— Science Students' Association
Manchester Literary and Philosophical Society
———— Microscopical Society
———— Museum Library
Marlborough College Natural History Society
Norfolk and Norwich Naturalists' Society
North Staffordshire Field Club
Nottingham Naturalists' Society
Plymouth, Marine Biological Association of the United Kingdom
———— Institution and Devon and Cornwall Natural History Society
Quekett Microscopical Club
Royal Irish Academy
Royal Microscopical Society
Rugby School Natural History Society
Torquay Natural History Society
Yorkshire Geological and Polytechnic Society
———— Naturalists' Union
———— Philosophical Society

OUR "PROCEEDINGS" ARE SENT AS A FREE GIFT TO:—

British Museum Library	Edinburgh, Advocates' Library
Cambridge University Library	Oxford, Bodleian Library
Dublin, Trinity College Library	Patent Office Library, London

AUSTRALIA.

Australasian Association for the Advancement of Science
New South Wales, Geological Survey of
————————— Royal Society of
Queensland Museum, Brisbane
Victoria, Royal Society of

CANADA.

Canadian Institute, Toronto
Hamilton Scientific Association
Nova Scotian Institute of Natural Science (Halifax)

INDIA.

Agriculture, Imperial Department of
Geological Survey of India, Calcutta

FRANCE.

Lyons, Société Linnéenne de
Rennes, University of

NORWAY.

Det Kongelige Universitet Christiana

SWITZERLAND.

Lausanne, Société Vaudois des Science Naturelles
Zurich, Naturforschende Gesellschaft

UNITED STATES.

American Museum of Natural History, New York
Augustana College, Rock Island, Illinois
Boston, Mass., Natural History Society
Brooklyn Institute of Arts and Sciences, Coldspring Harbour
California, University of, Berkeley
Californian Academy of Sciences, San Francisco
Cincinnati Natural History Society
————, Lloyd Library
Colorado College, Colorado Springs
————, University of, Boulder
Denison Scientific Association, Ohio
Elisha Mitchell Scientific Society, Chapel Hill, N.C.
Essex Institute, Salem, Mass.
Illinois, University of, Urbana
Indiana Academy of Science
Michigan Academy of Science
Missouri Botanical Gardens
———— Academy of Science, St. Louis
New Mexico, University of, Albuquerque
Ohio, State University, Columbus
Oklahoma State University
Philadephia Academy of Natural Sciences
————, Wagner Free Institute of Science
Smithsonian Institution, Washington
Tufts' College, Mass.
United States Geological Survey, Washington
———— National Museum, Washington
Yale University, Connecticut

ARGENTINE REPUBLIC.

Buenos Aires, Muses National de Historia Natural

URUGUAY.

Montevideo, Museo Nacional de

MEXICO.

Mexico, Sociedad Cientifica

Entomological Section, 1922.

THE season opened at the Museum with a joint meeting of this Section and the Entomological Section of the Somerset Archæological and Natural History Society. Four short papers were read, viz. :—" Plant Galls," by Miss Roper, " Collembola," by Mr. H. Womersley, " Psocidæ," by Mr. J. V. Pearman, and " Mallophaga," by Mr. Coldstream Tuckett. The papers were illustrated by specimens and coloured drawings. Mr. A. D. R. Bacchus exhibited a number of excellent coloured enlargements of the British Hemiptera.

The papers named were particularly interesting and welcome, because the study of the neglected orders of insect life have hitherto received but little attention in the South of England. To judge from the success obtained in securing many specimens of spring tails, plant lice and lice that feed on the feathers of birds, the Bristol district should prove productive of numerous species.

Papers have been read by Mr. Pearman on Orthoptera, illustrated by British species of the order, and by Mr. Bacchus on the bug *Nabis latioentris*, also illustrated by specimens and coloured drawings.

A large number of exhibits have been made by members at the meetings, both of specimens and microscopic slides, the following being the most noteworthy :—

Mr. G. C. Griffiths and Mr. W. Griffiths. A large number of rare and local Lepidoptera.

Mr. C. Bartlett. Many species of Coleoptera and Lepidoptera.

Miss M. M. Selman. British Odonata.

Miss I. M. Roper. Specimens of *Veronica anagallis* with galls caused by the presence of the beetle *Gyometron villosulus*.

Mr. T. F. Hewer. British Orthoptera.

Mr. H. Womersley. *Tropida scita*, a new record for the County, and Dr. Blood reported taking with Dr. J. P. Kryger a new genus and species of *Mymaridæ* at Brockenhurst, in the New Forest, the type, a male, being sent to the British Museum. The species is named and described in the " Entomologists' Monthly Magazine," 1922, p. 229, as *Petiolaria anomala*.

Dr. Blood is giving in the current " Proceedings " an account of his work on the *Mymaridæ*, an Order of very small iridescent flies.

Excursions have been taken to Ashcot on June 3rd, jointly with the Entomological Section of the Somerset Archæological and Natural History Society, which was a great success, the day being fine and many interesting captures made ; and another to Dursley, on June 17th, did not prove so productive as anticipated.

The year closes with a membership of 29.

CHARLES BARTLETT,

Hon. Secretary and Treasurer.

Geological Section, 1922.

THE membership of the section now stands at 26, as against 33 at the end of 1921, the decrease being almost entirely due to the resignation of student-members consequent on the formation of the University Geological Club. Although the membership is small, it is to be recorded that each member is a " live " one and has paid the subscription to date.

It is with regret that we place on record the death during the past year of two of our oldest members—Messrs. J. C. Blackmore and J. T. Underhill.

At the Annual Meeting held on January 26th, 1922, both the President, Secretary and Treasurer were re-elected. Seven meetings were held during the year with an average attendance of 19 :—

Jan. 26.—Exhibition Meeting.

Feb. 23.—" Flint Implements in the Bristol District." * R. H. Fitzjames

Mar. 16.—" Graptolites." Dr. G. L. Elles.

Apr. 27.—" China Clay and Associated Deposits of Cornwall." H. T. Harry.

Oct. 19.—" Notes on Some Alpine Glaciers." * The President, Prof. S. H. Reynolds, M.A., Sc.D.

Nov. 16.—" The Occurrence of Ores Locally."* H. F. Barke, F.I.C.

Dec. 14.—Exhibition Meeting.

* *Illustrated by specimens or lantern.*

During the summer months the following excursions were held with an average attendance of eight.

Apr. 22.—Messrs. J. S. Fry's new Works at Keynsham. Leader, Mr. J. W. Tutcher.

May 24.—Blaize Castle Woods. Leader, Prof. S. H. Reynolds, M.A., Sc.D.

June 24.—Avon Gorge (left bank). Leader, Mr. F. S. Wallis, M.Sc.

July 22.—Hanham and Conham. Leader, Mr. T. R. Fry.

The financial statement shows that a balance due to Treasurer of 15s. 4d. has been changed into a balance in hand of 6d. Not excessive wealth, but our first yearly account with a credit since 1917.

The subscription to the Palæontographical Society has been continued, though unfortunately for the first time in the history of the Section, the subscription to the Geological Magazine has been dropped, owing to our financial situation. As this is the first break in the sequence since Vol. I. of this important magazine, it is to be hoped that some arrangements will be made during the coming year for its continuance.

A working arrangement has been agreed upon with the Geological Section of the Bristol Field Club whereby members of either Geological Section are admitted to each others meetings. Whilst this Section still continues to base its papers on more detailed geological work, the Bristol Field Club confines itself to work of a more general and elementary character. The combination holds forth promise of infusing new life into both Sections.

FRED S. WALLIS, F.G.S.,

Hon. Secretary and Treasurer.

Ornithological Society, 1922.

Honorary President: Professor C. Lloyd Morgan, LL.D., F.R.S.

Acting President: Dr. A. L. Flemming, M.B.

After a lapse of many years the Ornithological Section of the Society has been revived. At a meeting held on the 30th November, 1922, at 5, Beaufort Buildings, Clifton Down, Dr. Flemming in the chair, it was decided to apply to Council for sanction to form this Section, and it was obtained.

The main object of the Section is to enable members interested in any aspect of Ornithology to meet together for the discussion of points of interest. It is necessary for the success of the Section that its proceedings should be conducted as informally as possible, but it is absolutely essential that members should bring to each meeting such exhibits as they can, and join in the discussion which takes place. Everyone who thinks must have his or her own opinion on the different subjects considered. None of us pretends to be that unfortunate being "an authority." Consequently all opinions will depend for their worth on the degree and quality of observation behind them. It has been noticed with regret that members of local audiences have usually very great reluctance to join in discussion or dispute any inference or statement put forward. It is hoped that in this Section we shall not be barred either by a sense of over-politeness, or by a feeling of personal lack of knowledge from questioning or adding to statements already made. There is probably very little that pleases a lecturer more than an animated discussion afterwards.

It is early yet to say exactly along what lines the Section will develop, the wish is rather to be practical than popular and to deal mostly with points arising about the structure of birds, points for instance which show how long habit and custom have brought about differences between species and species, or between birds as a whole and their relations. We do not, however, wish to tie ourselves to any given line, and it is particularly desired that members will suggest subjects that they would like to hear discussed. In this respect it may be well to mention that field parties will not be organised except on rare occasions to some particularly favourable place. This does not, of course, mean that the Section does not believe in the value of field work. That would be absurd, for field work is inseparable from useful, indoor work. At the same time it is impracticable for more than three or at the most four people together, to do good observational work at any rate as far as Ornithology is concerned.

COLDSTREAM TUCKETT,
Hon. Secretary and Treasurer.

Account of the Annual and General Meetings.

THE 59TH ANNUAL MEETING.

January 18th, 1922.

Mr. H. Womersley was elected President, and Mr. Thomas Morgans and Mr. James Rafter, M.A., Vice-Presidents, with minor alterations in Council.

The retiring President, Dr. E. H. Cook, D.Sc., the Lord Mayor of Bristol, delivered his presidential address for the third year, entitled "Milk" (printed in full on page 245).

THE 493RD GENERAL MEETING.

February 2nd, 1922.

"Diurnal and Nocturnal Lepidoptera," by Mr. William Griffiths.

The life histories of the Butterflies and Moths are an excellent study, because of the variety met with in the changes from egg to the full-grown insect. Whilst there is no distinguishing feature between the two families, if the Lepidoptera of the whole world were taken into account, still they afford contrast in Britain, apart from the forms produced by teratology and variation.

Well-known caterpillars seek protection from enemies by the resemblance to twigs or leaves, by terrifying attitudes, and by similarity of colouration, and it seems certain the females of some butterflies change their own colour to that of the males, generally the more plentiful of the species, for the extra safety to be found in numbers.

Exhibit by Mrs. Sandwith of living material of *Tolypella glomerata,* a new record for N. Somerset.

THE 494TH GENERAL MEETING.

March 2nd, 1922.

The Lord Mayor of Bristol, Dr. E. H. Cook, invited the members to a Civic Reception at the Museum and Art Gallery to mark the honour done him by the Society, in electing him President for the past three years. At his wish, in order to introduce into the reception the novelty of a scientific aspect, the members set out a large number of exhibits of Natural History, which were added to by the Bristol Field Club and the Bristol Microscopical Society. The result was full of interest to the guests, numbering over 500, and members received the heartiest congratulations on the success of their efforts and the high quality of their many specimens.

Amongst the noteworthy exhibits were :—In Botany, Marine Algae, Prof. O. V. Darbishire ; Pond Life, Mrs. Sandwith and Miss Selman. Flora of a wood in winter, H. J. Gibbons ; Genus *Ranunculus* prepared for the herbarium, J. W. White ; Sand dune vegetation, H. S. Thompson ; Mycetozoa, F. W. Evens ; Spring flowers, Miss Roper ; Liverworts and Mosses, C. Hunter ; Limestone ferns, Miss Lee. In Entomology, Bristle tails, Spring tails and Horse flies, H. Womersley ; Bird parasites, C. Tuckett ; Dragonflies, including five new to Somerset, H. Slater ; Insect mimicry, Col. T. Jermyn ; Injurious insects, W. Griffiths ; Fairy flies, Beetles, Leaf butterflies, etc., by other specialists. In Geology, Types, and figured specimens of local Fossils, J. W. Tutcher ; Strontia, B. A. Baker ; local rocks and fossils, Prof. S. H. Reynolds and others ; Cornish minerals, Mrs. Vaughan and H. W. Turner. In Ornithology, Birds' eggs, W. Griffiths ; types of clinging, hard-billed and swimming birds, C. Tuckett and L. H. Matthews ; Stuffed birds and their organs of voice, Dr. C. K. Rudge. In Microscopy, Fairy flies, A. T. Davies ; Foraminifera, A. E. Boley ; Pollen, Dr. F. R. Rose, and other objects.

THE 495TH GENERAL MEETING.

April 6th, 1922.

I. "Vegetable Caterpillars," by Mr. G. C. Griffiths, F.E.S.

The caterpillar of Hepialidae pupates below ground in New Zealand and Australia, when the mycelium of species of Sphæria fungi gets inside and by growing kills it. With all the markings thus destroyed it is difficult to identify with certainty the species of the Moth, but probably *Portrea enysii* and *P. dinodes* are the two most affected. Local specimens of two Hepialus have been met with round Bristol attacked by Cordyceps fungi, and there are instances of other fungi on wasps, moths and true bugs occurring in the sub-tropics. Specimens and pictures of the various Vegetable growths were exhibited.

II. "Colouration of Birds' Eggs," by Mr. Coldstream Tuckett.

Whether white eggs are laid by gaily coloured birds like the kingfisher, woodpecker and parrot, nesting in holes, as a result of continuing the original colour of all eggs ; or because they need no protective colouration, or because Nature is economical in such nesting places, was set out. Since the shell is added round the yolk only 12 to 18 hours before the laying, it was suggested that with other birds the variations in markings of value for protection were acquired by heredity, and have become fixed for the species.

III. "The Herbarium," by Mr. J. W. White, F.L.S.

No herbaria could be formed before the reign of Queen Anne, because no such classified collections were possible until Linneus originated the binominal nomenclature. The advantages of neatness, order and industry were gained by the formation of such collections.

THE 496TH GENERAL MEETING.

May 4th, 1922.

"Chlorophyll," by Prof. O. V. Darbishire, F.L.S.

Chlorophyll is the green colouring matter of plants, and consists of four different substances, two of which are green and the other two yellow. It is of the utmost importance to plants, since it alone is capable of converting simple elements, taken in from the soil and air, into starch, one of the most essential foods of all green plants. Leaves are arranged so as to catch all the sunlight possible, because chlorophyll gets its energy from light, and cannot be formed without it. Mankind and all other animals are ultimately dependent for their food upon the vegetable world, and since no plants could exist if there were no chlorophyll, it is one of the most important substances in nature. It was by means of chlorophyll that the energy given out by the sun, thousands of years ago, was stored up to furnish our coal supply.

Exhibit by Mr. W. Griffiths of a box for the capture of insects in the field, which he had invented and patented.

FIELD EXCURSIONS.

Four excursions were held during the Summer of 1922, and were fairly well attended.

June 10th. Ramble from Patchway to Almondsbury Hill, with a visit to the charming garden of Mr. Hiatt C. Baker. He received the members, and showed them round his garden, pointing out the many curious shrubs and colour variations of rare hardy plants that flourish in the open. Members were entertained to tea.

July 12th. Ramble from Saltford to Keynsham by the side of the River Avon, where some rare water plants, including *Potamogeton Drucei*, and insects were secured. Mr. and Mrs. P. F. Gibbons entertained the members to tea.

August 19th. Ramble from Staple Hill to Bury Camp, Moorend, chiefly botanical.

September 2nd. Ramble to Barrow Hill and Bourton Combe. Insects were plentiful, and specimens of Collembola, Campodea, Diptera, Myrmica, etc., were taken. A fledgling of the Little Owl, *Athene noctua*, was also captured and released.

THE 497TH GENERAL MEETING.

October 5th, 1922.

"Earth Sculpture," by Mr. F. S. Wallis, M.Sc., F.G.S.

Geological processes are still constantly at work in the world either by denudation or deposition, with transportation between. Even an ordinary shower of rain has a small effect on the sculpture of the surface, and results in such formations as the earth pillars of Scotland and of the Continent. On a larger scale rivers wear away the earth, and in such an instance as our Avon Gorge the work has been done during vast æons of time, when the river had probably far more energy than at the present time. Other effects produced by glaciers, wind, plants and finally by waves were considered and illustrated by a series of slides.

Exhibit by Mr. W. Griffiths of four clouded yellow butterflies, *Colias croceus*, showing slight variations in eye spots, etc.

THE 498TH GENERAL MEETING.

November 2nd, 1922.

Exhibits of Natural History by the Members.

Objects of interest in Natural History were displayed by twenty exhibitors, and short talks were given about some of them. Dr. C. K. Rudge spoke on boring and burrowing Marine animals ; Mr. H. Womersley on Myrmecophiles and Dragonflies ; Mr. W. Griffiths on Insect Teratology and Pests ; Messrs. J. R. P. Heslop and G. C. Griffiths, F.E.S., on Lepidoptera captured locally, including the rare *Vanessa Antiopa* and *Drepania sicula ;* Mr. J. W. Tutcher on Fossil Trigoniæ illustrating ornament ; Mr. J. W. White on British Clovers ; and Mrs. Sandwith on Floral sports.

Coffee was served during the meeting.

THE 499TH GENERAL MEETING.

December 7th, 1922.

Discussion : " Present Position of Darwinism."

Mr. C. Hunter, M.Sc., who opened the discussion, stated that Darwin included all sorts of differences between individuals as affording the material upon which natural selection might be expected to operate. Actual observations seem to indicate that those individuals which depart least from the ideal type have the best chance to survive ; but further improvements in the same direction seem not to follow.

Mr. J. V. Pearman, who continued the discussion, pointed out that critics of Darwinism have urged that interbreeding would cause opposing variations to cancel out, and a difference of opinion has arisen with regard to the possibility of the inheritance of acquired characters.

Miss G. G. Gilchrist, B.Sc., then gave a summary of the work of Dr. J. C. Willis on the distribution of plants and animals. Dr. Willis considers in his book, which has been termed "Age and Area," that the dispersal of species is mainly mechanical—so much dispersal in so much time—and the largest families and genera in any country will be the oldest and will occupy the greatest amount of territory.

The evidence of evolution derived from fossil records was dealt with by Miss E. M. Lee, M.Sc., who pointed out that members of the "Osmundaceœ," a fern family, can be traced from the Upper Permian to the living *Osmunda Regalis* (Royal Fern) of to-day. Successive records of these show a definite anatomical progression.

The President, Prof. O. V. Darbishire, Messrs. H. S. Thompson, W. Griffiths and F. W. Evens also joined in the discussion.

In Memoriam.

CEDRIC BUCKNALL, Mus. Bac.

On December 12th, 1921, there passed away an old and talented member and past vice-president of this Society, one of the leading systematic botanists of the country—a man esteemed and respected both for his attainments and his demeanour.

Cedric Bucknall was born at Bath on May 2nd, 1849. He shared the tendencies of a musical family, and at fourteen was the organist of a country church. Adopting music as a profession he speedily attained prominence as an executant and composer, qualified for the degree of Mus. Bac. in Keble College, Oxford, and married in 1873, whilst holding an appointment at Southwell Minster. Three years later he became organist and choir-master at All Saints, Clifton, and there continued until his death. Under his direction the choral and orchestral music of the church was developed and perfected. An *In Memoriam* notice in the All Saints' Parish Magazine for January speaks of his mastership of plainsong and the marked beauty and fluency of his improvisations on the organ; and testifies also to the impression made by "his humility, his calm, tact and gentleness, and his thoroughness and devotion to duty."

A serious student from youth to age, Bucknall had long been attracted by the mystery of the stellar universe and by that of its minutest organisms, finding recreation alike in astronomy and the microscope. His addresses at our evening meetings are remembered for their careful preparation and accuracy of statement, qualities which to his mind far outweighed the charm of ornate fluency or humour. From diatoms and desmids Bucknall turned to fungi. The latter group engrossed his leisure for many years; his "Fungi of the Bristol District" (1878—1891), published in our *Proceedings*, contained 1,431 species with excellent drawings fo the more interesting. More than a hundred of these were new

to Britain or to science. Of the figures in Cooke's *Illustrations*, forty-four were taken from Bucknall's coloured drawings of Bristol specimens. When the supply of fungi failed him, Bucknall gave attention to flowering plants with the same assiduity and methodical care that characterised all his work. Although this branch of botany was comparatively new to him, his industry and capacity for dealing with difficulties soon secured him a standing among systematists. His critical "Revision of the Genus Symphytum" (*Journ. Linn. Soc.*), and his work among the Eye-brights, published as a supplement to the Journal of Botany in 1917, enhanced a reputation already well founded; while his discovery near Wotton-under-Edge of *Stachys alpina*, a plant previously unknown in Great Britain, aroused keen interest among the botanists of the country. Bucknall was one of those who founded the University Botanical Club for students of field botany, and no member was more welcome at the fortnightly meetings when his engagements permitted attendance. For his friends could always reckon on sympathetic help with puzzling exhibits, and the reasoned judgment that his wide botanical knowledge enabled him to give on critical plant specimens often removed all doubt on their determination. In this way and by papers and demonstrations willingly furnished, his influence on juniors and beginners was at all times a stimulus and encouragement.

During the latter half of his life Bucknall made many Continental trips, collecting plants and acquiring a good knowledge of the flora of Central and Southern Europe. In the course of these travels and in the work of determining his gatherings he had learnt to read at least six languages and could converse in four. It is decided that his extensive herbarium will remain in Bristol.

Prior to the interment at Canford on December 16th a Solemn Requiem was sung at All Saints. The large congregation bore testimony to the widespread affection felt for our lamented friend.

J.W.W.

PRESIDENTIAL ADDRESS, 1922.

"MILK."

By E. H. Cook, D.Sc. (Lond. & Bris.), Lord Mayor of Bristol.

When I had the honour of addressing you as President in 1920 and again in 1921, water formed the principal subject of consideration ; to-night I propose to speak about a substance with which water is closely associated both rightly and wrongly. I mean Milk.

It is not the purely local variety known all over the world as " Bristol Milk," with which Lord Mayors of this city are supposed to be fairly well acquainted ; nor the delightful possession that Shakespeare has called the " Milk o' human kindness," which the wonderful response to my appeal for a Christmas Dinner Fund shows to be very abundant in Bristol. No, the subject of my address to-night is the common white fluid secreted by the mammary glands of all mammals, and which constitutes the sole food of this kind of animal when quite young.

The general composition of the milk of all mammals is similar, although great variations of the amount of the individual constituents are found. The fluid consists of a mixture of water, fat, sugar, nitrogenous substances which we may call casein, and mineral constituents. The proportions in which these are mixed not only varies with the species, but also with each specimen of the species, and also with the time when the sample was taken. Comparatively little study has been given to the milk of any other animal than the cow, but analyses have been made of the fluids given by many others. In regard to the cow, its milk has been analysed more times than any other substance. Thousands of analyses are made every day, and many well-established facts have been discovered relating to its variation in composition. In the following table I have given the average composition of the milk from four animals, each of which is used for human food :—

	Cow.	*Goat.*	*Ass.*	*Woman*
Water	87.35	86.04	90.12	88.5
Fat	3.75	4.63	1.26	3.3
Sugar	4.75	4.22	6.50	6.7
Casein	3.40	4.35	1.66	1.3
Ash	0.75	0.76	0.46	0.2

It will be seen that the differences are well marked.

Medical men are well acquainted with the fact that trouble often arises when infants are fed with cow's milk. In order to prevent this, some dairymen have taken to preparing and selling what they call " Humanized Milk." From the numbers given in

the table the mode of doing this can be understood ; the fat is slightly reduced ; the casein and ash largely, whilst the sugar has to be increased.

FAT.

The Fat is interesting because it is present in the form of small *transparent* globules varying in size from 0.01 mm. to 0.0016 mm. in diameter. Under the microscope they are colourless as well as transparent. But milk is certainly white and opaque. How is this ? Because of the dispersion of the light by innumerable reflections and refractions on its entering and leaving the globules.

Chemically, milk fat, *i.e.*, butter, is a mixture of the glycerides of several fatty acids : principally butyric, oleic, myristic and palmitic.

Of course, milk fat is lighter than water ; its specific gravity being given as 0.98. Hence the " rising of cream."

The exact process which takes place when butter is made, *i.e.*, what is called the " coming of the butter," is not very well understood, and is still the subject of controversy ; but the result is that the individual globules of fat coalesce to form a granular mass.

SUGAR.

The sugar in milk is not the same substance as ordinary cane sugar, although it is crystalline and has the same chemical formula. It is not so sweetening as cane sugar, but is more easily digested.

There is some evidence that the sugar contained in the milk of all mammals is not the same.

Milk sugar is made on the large scale and is an article of commerce, being used in medicine and in Infants' Foods.

CASEIN.

This name undoubtedly includes mixtures of several substances of the same or similar chemical nature. They all, however, contain nitrogen as an essential element and are all of the general character of substances known as " Albumins."

On the addition of an acid or the substance known as " Rennet," some milks are coagulated into " Curds " and " Whey." The curd is finely divided, pressed to remove water, and allowed to " ripen," and forms cheese.

Casein is prepared for commerce. It forms a part of many food preparations sold under fancy names all warranted to cure all the ills that flesh is heir to. One use of casein that will perhaps surprise many is that it forms a part of several preparations used as distemper for colouring walls.

THE ASH.

The ash of milk consists almost entirely of the phosphates of Calcium and Potassium, together with chlorides of sodium and potassium. This is the composition of the mineral matter as left after burning, but does not necessarily show how the elements are combined in the milk.

ANALYSIS AND ADULTERATION.

I have said that of all substances milk is the one that is analysed most often. But fortunately for the Public Analyst it is not necessary to make a complete analysis such as that given in the table. All that is required is to find the amount of fat, and of the other solids clubbed together.

The difficulty about arriving at a decision as to whether a given sample has been adulterated or not, is that the liquid itself is of so variable a composition. The quality is affected by the breed of the cow. For example, a little Guernsey or Jersey gives a very much richer milk on the whole than a Shorthorn or Freisian. It is also affected by the time of milking, both daily and after the time of calving. The nature of the food affects both the quality and the quantity. When these facts are remembered, and also that, unless the water added for adulteration possesses some substance dissolved in it, which is easily detected, it is impossible to distinguish between the natural water in the milk and the added water ; the difficulty in detecting adulteration becomes evident. The method adopted has therefore been to fix certain figures founded upon the results of thousands of analyses and to call that the milk of standard composition. The figures adopted are :—

Solids not Fat	8.5 per cent.
Fat	3.0 ,,

and it is assumed that if a sample contains say 8.0 per cent. of solids then it has had water added to it ; if it contains 2.75 per cent. of fat it has had cream abstracted from it. This assumption is not quite correct because at certain times some few samples may fall below, but the yield of a herd of cows of mixed breed very seldom falls below. Strangely enough, however, when the standard was first adopted Earl Rosebery was Prime Minister, and it was determined to test the soundness of the figures by experiments upon the herd at the Home Farm at Mentmore, his residence. This was accordingly done, and the yield was found below the standard ! Explanations were, however, forthcoming, and no change was made in the figures.

Numerous experiments have been made, and it has been found that out of 100,000 samples examined—

732 gave less than 3.0 per cent. of fat,
and 2,193 ,, ,, ,, 8.5 ,, solids not fat.

It will therefore be seen that the standard is very satisfactory. In order that injustice may be prevented as far as possible, it is specially enacted that where a sample falls below and is claimed as abnormal, a special appeal may be made to the cow. Abnormal specimens may, however, easily be obtained if the farmer is not careful. As one who has been studying these points for many years and who is brought face to face with the problem practically every day, I would advise that care should be taken to mix the whole yield from a single cow, and also to mix that of the herd before sending to market.

It would be far too technical, and also tedious to go into the niceties of the methods adopted for the adulteration of milk. I therefore turn to another portion of my subject, viz., to consider the production of milk as if it were a manufacture. It may be regarded as somewhat derogatory to speak of milk-raising as a manufacture, and yet it is similar. The manufacture of iron is an industry comparable in size to that of milk-making. The iron is made by means of an appliance called a blast furnace ; milk is made by means of an appliance called a cow. Iron ore, limestone, and coal are fed into the mouth of the furnace and the manufactured article drawn off at a suitable part of the structure. Similarly grass, hay, mangolds, etc., are fed into the mouth of the cow and the milk drawn off at the udder. Moreover, the amount of iron produced bears a known proportion to the amount of iron contained in the ore with which the furnace is supplied, and if a serious falling off in the yield takes place the ironmaster knows that either the furnace is not doing its work properly or something is wrong with the mixture put into it. Careful scientific study has shown what ought to be done and how defects can be remedied. Has any similar study been made with regard to milk ? Up to quite recently I think I should have been justified in saying that nothing had been done. Of recent years, however, a beginning has been made, but accurate data are not yet forthcoming.

The first step in the investigation was to get an idea of what the machine really does. For some time past at many Agricultural Stations in America Milk Records have been kept, and, fostered by our Board of Agriculture and Fisheries, numerous Societies have recently been established in this country. From these we are getting valuable statistics as to the yield and in some cases quality also.

So long ago as May, 1905, our Ministry issued a leaflet pointing out the value of keeping records of the milk yield of cows and advocating the formation of Milk Recording Societies. This advocacy was just beginning to be effective, when the blight of 1914 and subsequent years fell upon the world, and no progress was made. Since 1918, however, the importance of the subject has again become evident, and consequently the original leaflet was revised

and re-issued in May, 1921. The advantages to be derived from a careful series of records are many. An ailing cow or cows are quickly detected, feeding may be carried out more economically, influence of a change of food or climate is quickly noted, influence of breed and selection of cow are shown, and finally much more interest is taken by the farmer and stockman in their labours.

Our Ministry are making strenuous efforts to improve the breed of dairy cows, and are so impressed with the importance of accurate data that they are giving grants to Milk Recording Societies of £3 10s. per annum per herd recorded. They also issue a register, in which is included the name, age, pedigree and "performance" of every cow that has (1) Yielded not less than 8,000 lbs. of milk during a year, and (2) Yielded not less than 6,500 lbs. on an average of two or more consecutive years.

These are steps in the right direction, and results may be expected that will be of advantage to the farmer and the general public. Striking conclusions have been obtained from the figures given in this Register and the competitions, etc., held at the various Agricultural and Dairy Shows up and down the country.

For many years the Friesian cow has been regarded as the milch cow of Northern Europe, America, Canada and our Colonies, but for some reason it is only just coming into prominence in this country. It is not what I may call an "artistic" animal. It hasn't the fine outline of our Shorthorns or Herefords, or the fine colouring of our Devons and Jerseys, but its remarkable pre-eminence as a milker is making it very popular.

Two years ago it was not known that any cow gave more than 2,000 gallons of milk a year. But now 26 cases have been recorded, and one of 2,500. All these, with one exception, are British Friesians. Moreover, the official record shows that 35 per cent. Friesians are 1,000 gallon cows, and that the next highest are cross-breds with 19 per cent. Moreover, it is the only breed producing 1,000 lbs. of butter a year, and is the only breed including cows giving 10 gallons a day each.

Hitherto, English farmers have paid attention almost exclusively to the beef-producing capacity of the cow, and very successfully too, for English beef is the best in the world. But they will now have to pay more attention to the milk-giving power as well. The commercial and economic importance of the matter may be brought home by one fact. The Government finds from a census taken of dairy cows that the average cow gives 1.3 gallons per day only! It would be a very poor herd of Friesians that did not average 2.6 gallons per day, or twice as much as at present, and a corresponding diminution of the price of milk ought to result.

The percentage of fat in the Friesian is not quite equal to that of some of our other breeds, but the difference is not very marked on the average.

From the foregoing data we can indicate the beginning of the scientific study of our manufacture. Ten gallons a day would weigh about 103.2 lbs. Let us take 100 lbs. in round figures as the daily production and the amounts of the individual constituents will be exactly those given in the table. Since the 100 lbs. of milk contain 87.35 per cent. of water it is obvious that that amount of water must be taken daily at least. That is, $8\frac{3}{4}$ gallons. The provision of the necessary amount caused farmers a good deal of trouble during the late drought.

Confining attention to two chemical elements, viz., Nitrogen and Phosphorus, the table shows that a 10-gallon cow gives about half-a-pound of Nitrogen per day and about one-tenth of a pound of Phosphorus. It is therefore necessary that its ration should contain these substances in those amounts. Meadow hay and clover hay mixed may be taken as containing 3 per cent. of Nitrogen (*Analyst*, vol. 23, p. 48) ; therefore, the cow will require about $18\frac{1}{4}$ lbs. of such fodder daily. In a similar way we can ascertain the amount of Phosphorus-bearing food that must be fed into our machine to produce the product required.

It is, of course, obvious that the problem is not so easy as I have represented, because we are only imagining that the feed has to contain just as much of the constituents as is given out by the milk. Of course, this is incorrect, for milk is not the only product made by the cow, and we also know that some constituents must be used up in adding to the bulk of the animal herself. Nevertheless, although the subject has only been partly studied, many glaring errors in feeding have already been remedied. Some carefully conducted experiemnts have been made, especially at the Agricultural Experimental Station of the University of Illinois, where the beneficial effects of a selected ration have been proved conclusively. Illinois, however, whilst a good dairy country, is not well supplied with pure-bred cattle, and the experiments took no account, so far as I know, of the Phosphorus ration.

The importance of the question is receiving attention in this country, and our agriculturists, who are not so unprogressive as some people think, have already made many observations of great value. Thus, I find in a small agricultural paper the following in answer to an enquiry :—

" The ration depends entirely upon the class or breed of the cow, and the quantity of milk she is giving. The grass becomes deficient in nitrogenous constituents during the autumn, so that it is necessary

to give a little concentrated food reasonably rich in albuminoids. As regards quantity, it is generally estimated that a cow giving two gallons of milk per day will require 4 lbs. of meal or cake, an extra pound being given for every additional gallon of milk produced."

There is here an attempt at a direct relationship between the milk yield and the ration. The figures quoted are interesting in relation to my own figures which I have just given, because the 10-gallon animal gives as we have seen about 12½ lbs. of *solids* per day. Therefore, 1 gallon will contain about 1¼ lbs., or a quarter of a pound more solids than the agricultural expert who writes the article quoted, states is "generally estimated" to be necessary to put in!! The cow could not last long under these circumstances.

The study of milk production from the scientific side has not hitherto received much attention, but it is hoped that our Board of Agriculture will soon be in a position to carry on continuous experiments which cannot fail to add to our stock of accurate information.

One last point. This substance forms the natural food of the mammal, but it also possesses the necessary constituents for the food of a lot of other things. It therefore almost always contains micro-organisms, some of which may be regarded as beneficial to the human animal, and others just the reverse. All these get into the milk after milking, or from the dirty hands of the milker. These micro-organisms are mostly slightly heavier than air and fall into the pails and pans into which the milk is placed. Too much care cannot be taken in regard to the milking of the cow and the storage of the milk. The cowshed should be well ventilated, the cows' udders and teats quite clean, the hands of the milker and the pails scrupulously clean, and everything around, including the air, as still as possible. The milk should be conveyed from one place to another in closed vessels, and stored in similar vessels when offered for sale. It is a very nice sight to see on the counter of a dairy shop a large bowl of milk with a yellow covering of cream, but it must not be forgotten that the extra surface exposed catches all the germs that fall upon it, with, it may be, disastrous results. The enlarged micro-photographs shown upon the screen illustrate these points.

Since the young mammal is built up entirely, for some short time after birth of the substances contained in milk, it follows that this substance contains all the chemical elements of which the body of the young animal is composed. It is, therefore an all-sufficient food. This is perfectly true of milk, but it is not true of other foods, as a general proposition.

It has been found that sometimes a chemically complete ration did not suffice for the full and healthy growth of the individual. Certain diseases, such as scurvy, rickets, etc., followed the use of special kinds of food, although every element was present. Further research has shown that these foods were without certain infinitesimal amounts of bodies of unknown composition, but which bodies undoubtedly had an important bearing on nutrition. To such bodies the general names of "vitamins" has been given. Conversely, these diseases are cured or ameliorated by the addition to the ration of minute quantities of these bodies. Experiments are still very incomplete, but it is supposed that it has been shown that three such bodies have been proved to exist :—*Fat soluble A*, in butter and other things ; *Water soluble B*, in Wheat germ, etc., and *Anti-Scorbutic*, in Cabbage, etc. Very few bodies contain all three, but the substance we have been talking about to-night does. The universal practical experience of mankind is, therefore, supported by scientific discovery. The word "vitamin" lends itself so readily to advertisement purposes, that a great deal of nonsense has been, and will be, written about the subject. It is too early as yet to draw sweeping general conclusions, but a promising field of discovery has been opened up which may have far-reaching influence upon the eternal food question.

In conclusion, I trust that it has been shown how wonderfully constituted a substance milk is, to act as a complete food, how essential each constituent is for its special work, and also how essential it is that the most scrupulous cleanliness should be exercised in every detail of its transference from the cow to the drinker.

NOTES ON TRICHOGRAMMATINAE TAKEN AROUND BRISTOL.

By B. N. Blood, M.D.

THE Trichogammatinæ are a sub-family of the Chalcididæ, and are recognised by their three-jointed tarsi, by their small size and lack of metallic colouring, and in some genera by the curious arrangement of the surface hairs on the wings, which are here arranged in regular rows radiating from the base, thus giving name to the typical genus—Trichogramma.

The sub-family may be conveniently divided into three tribes :

1. TRICHOGRAMMINI.—With many regular rows of hairs on the surface of the anterior wings, which wings are wide, and fringed with short cilia. The insects brown or yellow in colour.

2. OLIGOSITINI.—The surface hairs of the anterior wings not without a certain amount of regularity, but leaving bare patches on the wings, which wings are narrower and fringed with longer cilia. The insects are generally yellow in colour.

3. BRACHISTINI.—The surface hairs equally distributed al over the anterior wing (except at the very base). There may be one, two, or at most three regular rows among these hairs. The anterior wings are wide and fringed with short cilia. The insects are generally of darker colour—black, dark brown, or yellow, variegated with dark brown markings.

The following is a list of the British Trichogrammatinæ, of which I have caught all those marked with an asterisk (*) in the Bristol District :—

TRICHOGRAMMINI.

Poropoea stollwercki (Forster).
*Trichogramma evanescens (Westwood).
*Neocentrobia hirticornis (Blood).
*Centrobia walkeri (Forster).
*Centrobia forsteri (Kryger).
*Centrobia sylvestri (Kryger).
*Centrobia fumipennis (Blood).
*Ophioneurus signatus (Ratzeburg).
Lathromeris scutellaris (Forster).

OLIGOSITINI.

*Chaetostricha werneri (Kryger).
Chaetostricha dimidiata (Haliday).
*Oligosita subfasciata (Westwood).
*Oligosita collina (Haliday).
Prestwichia aquatica (Lubbock).

BRASCHISTINI.

Branchista pungens (Mayr) or (Haliday).
*Branchista nigra (Kryger).
*Monorthochaeta nigra (Blood).
*Asynacta longicanda (Blood).
*Orthoneura bimaculata (Blood).

TRICHOGRAMMINI.

Porpoea stollwercki can be distinguished by the rounded front wings, on which are about eight regular rows of hairs. The marginal nerve does not reach the front edge of the wing, and the female has a curved, sickle-shaped ovipositor as long as her abdomen. The antenna is not widened into a terminal club. This species is not yet recorded from the Bristol District, but I hope this spring to breed it from cocoons of *Attelabus curculionides*, of which I gathered many in Henbury Woods. My friend, Mr. J. Waterston, of the British Museum, has bred it in numbers from this host.

Trichogramma evanescens is distinguished from other genera of its tribe by the marginal nerve forming a regular S-shaped curve, and in this genus it touches the anterior wing border. There are about fifteen rows of hairs on the wing. The female antenna has six joints, the male antenna has four joints, the ultimate joint in each case forming a large club from which spring long curved hairs in the male. The male is dimorphic, an apterous variety with antenna almost like the female, being sometimes found. I have caught this insect all round Bristol ; it is a common species, breeding in the eggs of moths, butterflies, flies and stone-flies.

Neocentrobia hirticornis is distinguished in the male by the non-clubbed antennae, which are composed of ten joints, of which the six outer ones give rise to whorls of large curved hairs. The female is extremely like a Centrobia. In fact I hardly feel justified in forming a new genus for this insect, but that the male antenna is so characteristic and unique. I have caught a male and several females of this insect in the New Forest, and last Autumn caught three females in Brockley Combe. The ovipositor just reaches beyond the abdomen.

Centrobia walkeri.—I have given the generally accepted specific names for this and the two following insects, but in the future it is possible that priority will alter this nomenclature. The genus Centrobia has wings with hairs even more regularly in rows than Trichogramma. It can be distinguished from Trichogramma by the fact that the marginal nerve runs for some distance along the front edge of the wing, then dips suddenly down, ending in the wing in a rounded knob. All the species have a three-jointed antennal club. The species are distinguished by the length of the female ovipositor, and the males by minor differences in the wings.

The males can also be distinguished by comparison of their wings with the female—the same species having identical wings in both sexes.

Centrobia walkeri is fairly common round Bristol, the ovipositor is curved like a sickle, and is as long as the entire insect.

Centrobia forsteri has an ovipositor as long as its abdomen, it is rarer than *Centrobia walkeri.* I have found it at Nailsea and at Kings Weston Down.

Centrobia sylvestri has an ovipositor nearly half as long as its abdomen. It is rather rare around Bristol, but I have found both sexes at Southmead, and also in Brockley Combe.

Centrobia fumipennis has a short ovipositor, just reaching beyond the end of the abdomen. It is somewhat like the female of *Neocentrobia hirticornis,* but can be at once distinguished by the strongly infumate basal half of the wings, which also prevents the male from being mistaken for any other insect. The life histories of these centrobiæ, and also of *Neocentrobia hirticornis,* are unknown.

Ophioneurus signatus may be distinguished by the manner in which the two ends of the marginal nerve—especially the apical or outer end—are darkened. The antennal club is three-jointed and is rather hairy in both sexes. This is a rare insect in the Bristol area ; I have taken one female in Henbury Woods, and a second at Shapwick when sweeping small birch trees. This insect may be bred from the rolls made by the beetle *Rhynchites betulae,* on birch and alder trees.

Lathromeris scutellaris I have never seen. It has not been recorded since its first capture in 1856. It can be readily distinguished, as it is the only member of the *tribe* Trichogrammini, which has a four-jointed antennal club. Its life history is unknown.

OLIGOSITINI.

Chaetostricha werneri is our most common Trichogramma. The hemipterous male, and his larger winged mate, can be distinguished by the triangular and recurved shape of the end of the marginal vein, also by the very irregular lines of the surface hairs on the wings, and the seven-jointed antennæ, in which the three-jointed club is neither wide nor large. In all the Oligositini the cheeks are darker than the rest of the head, and as we learn more of the two genera Chaetostricha and Oligosita, they tend to blend together, until the only differentiating factor left is the presence of a dark wing mark behind the end of the marginal nerve in Oligosita, which is quite lacking in Chaetostricha. The life history of *Chaetostricha werneri* is unknown, it can be distinguished from the following species by the fact that the marginal nerve reaches well beyond half the entire wing-length.

Chaetostricha dimidiata I do not know. From descriptions it is like *C. werneri* except that the wings are larger and longer. If the end of the marginal nerve extends beyond half the length of the wing it is *C. werneri*, if, on the other hand, the end of the marginal vein extends only half the wing-length, then it is *Chaetostricha dimidiata*. I have never captured or seen this insect. Life history unknown.

Oligosita subfasciata is easily recognised by the very strongly marked spot in the substance of the wing, forming, with the dark end of the marginal nerve, a bar of brown right across the front wing. In this species, as in the following, the antennæ are composed of seven joints, of which the rather small club absorbs three. I have taken this insect in both sexes in the New Forest, and one female also on Kings Weston Down.

Oligosita collina. This may be distinguished by the comparatively faint wing-bar, and by its lighter colour and more slender build. The wings of the female are narrower than in *Oligosita subfasciata*, and the clear lemon-coloured male is micropterous. I caught several males of this on Kings Weston Down last year, and imagined I had discovered another new species. Later I caught one female at Shapwick, and then realised that the males I had caught were the hitherto undescribed mates of *Oligosita collina*, the female of which Haliday described so well. This writer had a wonderful gift for envisageing an insect by words, and is the best writer I know for this. The life histories of our Oligositæ are unknown.

Prestwichia aquatica. Famous because of its sub-aquatic method of living—it swims about under water by means of its legs, and is a parasite of the eggs of Ranatra and Noctonecta, the Dytiscus and perhaps other water-beetles, and several species of Dragon-flies. I have been sent specimens from the Midlands, but have not yet caught this insect near Bristol. Besides the winged females, there are hemipterous and apterous ones, the male being always apterous. It is the only species of the tribe Oligositini found under water, the only one in which the male is apterous and not lemon-yellow in colour, and in which the female has a protruding and powerful ovipositor.

BRACHISTINI.

Brachista pungens was first found by Andrew Haliday in England, but he gave us no description of the species, only describing it as a genus. This species was afterwards caught in Germany and there described. The wings are evenly covered with rather stout hairs, and the insect has a stout body and powerful ovipositor. The male is yet unknown. Dark brown in colour, one distinguishing characteristic of the two species of this genus is the number of

long stout body-spines, two of which, on the scutellum, curve upwards and forwards above the insects' head. *Brachista pungens* has not been caught in this country since Haliday's time.

Brachista nigra is much like the former species in size and shape, differing in the colour, which is black, and in the ovipositor, which is shorter than in *Brachista pungens.* I have caught three females of this species at Shapwick, where they are parasites on the eggs of water-bugs and water-beetles. The males are very similar in appearance.

Monorthochaeta nigra can be easily distinguished by the front row of surface hairs on the anterior wings. This row runs in a straight line to the anterior outer border. This insect is also the only one of the tribe Brachistini which has nine antennial joints and is also black in colour. The male is a strange little apterous creature with a large head and rotund abdomen, which at first sight reminds one strongly of a member of the spring-tail genus *Smynthurus.* I have caught several specimens of both sexes of this new insect on Kings Weston Down during 1921 and 1922. The life history is as yet unknown.

Asynacta longicanda is described from one female captured by me at Shapwick last Autumn. There are three lines of regular hairs—the first arched forward and reaching outward toward the anterior border of the wing, the second line starts from the same spot—the end of the marginal nerve—and is arched backward, reaching the tip of the wing. The third regular line starts close to the joint between the front and hind wings, and arching forward, runs outward towards the postero—external border of the wing. The wings and antennæ of my specimen correspond exactly with the type *Asynacta exigua* in the Vienna Museum, but the type there has a rounded abdomen with no protrusion of the ovipositor. My specimen has a powerful ovipositor about half as long as the abdomen, or more, so I feel justified in calling it a new species. The regularly curved marginal vein, which just reaches the anterior edge of the wing at one spot, and the three rows of regular hairs on the front wing, together with its black colour, are the distinguishing marks of this insect.

Orthoneura bimaculata is a species also new to science, and can be easily distinguished by the very straight marginal vein, which hardly dips at all into the wing—there is just a small notch at its outer end. Also the colouring of the thorax more particularly the two dark brown oblong spots—one on each side of the prothorax, narrowly separated by the light brown ground colour of the insect, make it quite easy to recognise. The sexes are nearly alike, the female perhaps a shade larger, but it is not good to go by size too

much in these parasitic insects, and an inverted or side view will at once decide the sex.

That I should be able to name my captures so well is due entirely to the excellent work which my friend, Mr. J. P. Kryger, has written, and also to the cordial help I have had from him in the fields, on many a pleasant day. A white canvas or "drill" sweeping net should be used to capture these insects among grass and on shrubs. Generally grass fields in woods, young plantations, and swampy fields yield the best results. The insects can only be confounded with some of the Chalcids of the family Aphelinæ, but when brought home, the microscope will at once show the three-jointed tarsi of the Trichogrammatinæ. The author will be only too pleased to help any reader who wishes to study these insects, which are really very little known, but are more interesting on that account.

Some Observations on the Resting Period of Twigs of Prunus Cerasus.

By CHARLES HUNTER, M.Sc., F.L.S.

THE occurrence and the continuance of the flowering periods of plants depend to a great extent on certain inherent factors, but climatic conditions may hasten or retard the arrival of such periods or may modify their duration. The study of the connection between meteorological conditions and the periodic activities of plants is known as phenology. Unfortunately the signification of this term is commonly restricted to the connection between the temperature of the atmosphere and the flowering of plants. It is generally recognised that temperature has an important influence on the time of flowering which is normally retarded by low temperatures and hastened by high temperatures. Temperature has been considered so important that tables have been prepared to show the total amount of heat necessary to induce the flowering of various species of plants. These tables are of but little value since heat is only one of the factors which affect the time of flowering. The flower buds of most spring flowering plants are normally formed before midsummer. Occasionally such plants flower in autumn if favourable temperature and moisture conditions continue to obtain for a sufficient period. The inadequacy of the phenological method of interpretation of the phenomena of the periodic activities of plants is apparent in the case of those buds which withstand many weeks of warm weather during the autumn without blooming, but proceed to this activity after the intervention of winter followed by only a few days of warm weather in the spring.

Direct experiment[1] has proved that higher temperature alone is not always sufficient to bring plants out of their resting condition into active growth. Twigs of *Prunus avium* were removed from a tree at intervals throughout the winter and placed in a greenhouse with a temperature of from 20° to 25° C. Twigs cut in the autumn failed to produce leaves or flowers and finally died, while those cut during the winter and early spring flowered after they had been exposed to the greenhouse temperature for a certain time, this period becoming shorter with the advance of the season. The number of days of greenhouse conditions required to produce flowers on twigs of *Prunus avium* is shown in the accompanying table.

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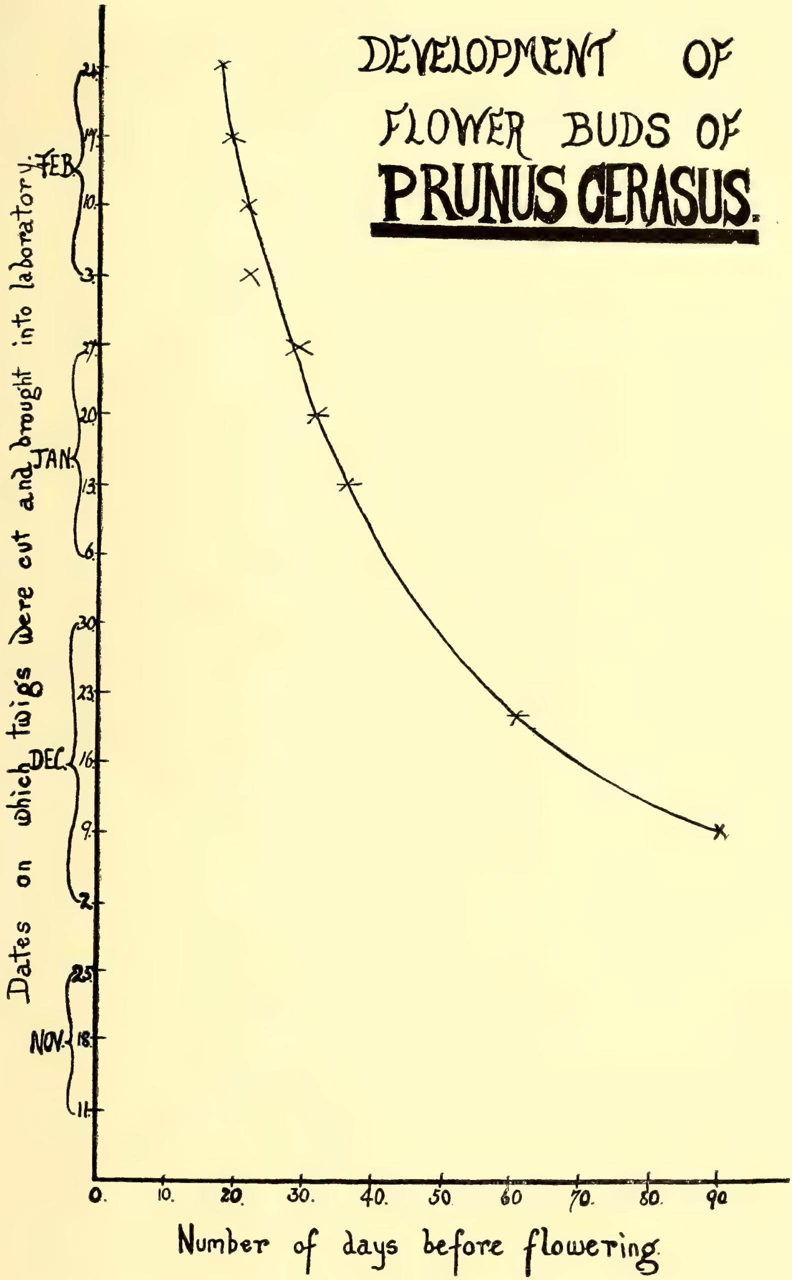
(1) Palladin, V. I.—Plant Physiology (1914), translated by Livingston, 1917. P. 227.


DEVELOPMENT OF FLOWER BUDS OF PRUNUS CERASUS.
Dates on which twigs were cut and brought into laboratory.
FEB.
24.
17.
10.
3.
JAN.
27.
20.
13.
6.
DEC.
30.
23.
16.
9.
2.
NOV.
25.
18.
11.
0.
10.
20.
30.
40.
50.
60.
70.
80.
90.
Number of days before flowering.

Date of Cutting and Placing in Greenhouse.	Period Required to Produce Flowers.
December 14th	27 days
January 10th	18 days
February 2nd	17 days
March 2nd	12 days
March 23rd	8 days
April 3rd	5 days

In some comprehensive experiments which were carried out at Halle, Germany,[2] 234 species of woody plants were brought into a greenhouse between October 28th and November 4th and were kept under greenhouse conditions throughout the winter. One hundred and twenty-five species began to make growth within two weeks ; the twigs of seventy species began to develop in the following February ; and those of thirty-six species did not become active until the month of March. From these data it would appear that favourable conditions for growth greatly reduce the normal rest period for a large number of deciduous trees and shrubs.

The results of such experiments as those mentioned above probably depend largely on the condition of the buds at the time of the inception of the experiments. It is known that in many instances there is a gradual accumulation of food material during winter, both within the buds as well as in their vicinity in the stem, which is utilised when favourable conditions for development return. The insufficiency of available food is one of the chief reasons for the absence of development in certain buds when exposed to favourable conditions during their resting period.

Observations made during the months of November and December, 1921, and of January, February, and March, 1922, on the development of buds of *Prunus Cerasus* are of interest in connection with the problem under consideration. After the tree selected had lost its leaves in the autumn of 1921 twigs were removed from it each week (with one exception) from November 11th to February 24th. These were brought into the Hiatt Baker Laboratory of the University, placed with their cut ends under water, and kept under greenhouse conditions until the close of the experiment. During this period the temperature of the laboratory remained at 23° C. $\pm$ 2° C. The water in which the twigs were placed was changed each week, and a small portion from the base of each twig was cut off in order to prevent the wood vessels from being choked

(2) Howard, W. L.—Untersuchungen ueber die Winter-ruheperiode der Pflanzen. Inaugural-Dissertation, Halle.

by small particles of solid material present in the water, or from becoming occluded owing to the formation of wound gum in them. The first indications of the bursting of the buds were noted and also their dates of flowering. The results obtained are recorded in the table below, and they are also expressed graphically.

Date of Cutting and Placing in Greenhouse.	Date of the first indication of bursting of buds.	Date on which the twigs flowered.
1921 Nov. 11th	—	—
Nov. 18th	—	—
Nov. 25th	—	—
Dec. 2nd	—	—
Dec. 9th	Feb. 24th, 1922	March 9th, 1922
Dec. 21st	Feb. 3rd	Feb. 20th
1922 Jan. 13th	Feb. 3rd	Feb. 18th
Jan. 20th	Feb. 3rd	Feb. 20th
Jan. 27th	Feb. 10th	Feb. 18th
Feb. 3rd	Feb. 10th	Feb. 24th
Feb. 10th	Feb. 24th	Mar. 3rd
Feb. 17th	Feb. 24th	Mar. 8th
Feb. 24th	Mar. 3rd	Mar. 14th

Although these observations are in accord with the data previously quoted for *Prunus avium* in that the twigs brought in prior to December 9th failed to develop further, yet they differ in that the time of flowering was advanced by this treatment for *Prunus avium,* whereas in the case of *Prunus Cerasus* this did not occur to such a marked degree.

One of the twigs brought into the laboratory on December 9th was for some time in such a position that the lowermost spur was submerged in water. On February 3rd it was noticed that the terminal bud of this spur showed signs of bursting, and on February 24th it was fully open. This bud developed thirteen days earlier than any of the other buds on the twigs brought in on December 9th. It would appear, therefore, that the development of this bud was due to its immersion in water. None of the buds on twigs brought in before December 9th showed any signs of development, and so a twig removed from the tree on November 25th was submerged in water from February 11th for one week. Seven days later the buds on this twig showed signs of bursting.

This would seem to indicate that the treatment of submerging the twigs for a time in water has a beneficial effect on the subsequent development of their buds, and also that the relatively dry atmosphere of the laboratory might to some extent have prevented the development of the buds on the twigs brought into the laboratory before December 9th.

Another interesting exception to the data recorded above occurred in the case of a twig brought into the laboratory on December 2nd, and whose apex was removed. On February 18th a foliage bud immediately below the wound showed signs of bursting, and it had completely opened on February 24th.

Micro-chemical tests for the presence and distribution of starch, sugar, proteins, and fats in the stems and buds were conducted at weekly intervals throughout the period of experiment. During the earlier months starch formed the preponderant carbohydrate reserve so long as the buds remained in their resting condition. A pronounced increase in the amount of sugar present in the tissues always preceded the development of the buds. In consequence of this observation a twig which had been brought into the laboratory on November 25th was placed with its cut end in a 0.1 % solution of glucose on February 17th and left for a week after which it was replaced in water. This twig showed signs of the buds bursting on March 3rd, *i.e.*, fourteen days after the treatment was commenced. Müller-Thurgau[3] and Detmer[4] came to the conclusion that an accumulation of sugar was necessary in order to ensure that energetic growth of the buds of potato tubers should take place. According to their experiments the abundant production of sugar as the result of more intense action of diastase on the starch present in the tubers accompanied the development of the buds. It is very probable that these results regarding the termination of the resting period of potatoes are of significance in explaining the resting period of the winter buds of our trees and shrubs.

The observations recorded above prove that the resting period of twigs of *Prunus Cerasus* may continue in spite of temperature conditions usually favourable to active growth, and that the ultimate development of the buds is not governed entirely by the external conditions prevailing.

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(3) Müller-Thurgau.—Landwirthschl. Jahrbücher, Bd. 11, p. 813.

(4) Detmer, W.—Pflanzenphysiologische Untersuchungen über Fermentbildung. Jena, 1884, p. 41.

Bristol Botany in 1922.

By Jas. W. White, F.L.S.

Some curious departures from the normal cycle of plant-life, resulting from the unusual weather conditions of the last two seasons, have not escaped remark by ramblers interested in botany. Many herbaceous spring-flowering species, dried up and withered in a too early stage of development, bloomed a second time in the autumn after re-animating rains ; and the smaller annuals that had been hurried to maturity by heat and drought in May actually reproduced themselves in another generation before the close of the year.

Observations in the field kindly placed at my disposal since the last instalment of these notes was published make it clear that the Bristol district is still far from having been despoiled of all its botanical secrets. My cordial thanks are once more offered to those friends and correspondents whose records follow in due order.

Moenchia erecta Gaertn. Has been detected in two additional stations in West Gloucester—at Bury Camp, Moorend ; and on Syston Common ; *H. J. Gibbons.*

Stellaria Boræana Jord. Rocks and sand-hills at Uphill, S. ; *Miss Roper and N. Y. Sandwith.*

Vicia sativa L. var. *macrocarpa.* Determined by Mr. H. S. Thompson. An enormous plant (stems 6 ft.), on an allotment border at Horfield ; *H. J. Gibbons.*

Saxifraga granulata L. Has unfortunately been destroyed on the G.W.R. embankment in Keynsham Hams by fires along the line.

Bupleurum tenuissimum L. Plentiful on the edge of Durdham Down along the Upper Belgrave Road, and more sparingly elsewhere towards the Zool. Gardens. The main patch is near the site of a filled-in quarry, but as in that instance no soil was brought from the river side the plant may be indigenous.

Crithmum maritimum L. Still exists on shingle below New Passage, G., where it was observed in 1910 by E. M. Day.

Eupatorium cannabinum L. With white flowers under Cook's Folly Wood ; *Miss Roper.*

Antennaria dioica Gaertn. A tiny patch, with one stem in flower, on a rocky slope near the upper end of Cheddar Gorge ; *E. J. Hamlin.*

Cirsium eriophorum (L.) Scop. In the *Gardeners' Chronicle* for October 14th Mr. H. S. Thompson describes—and illustrates with a photograph—the remarkable abundance of this handsome thistle in the Chew Valley of North Somerset. Dr. Petrak, monographer of the genus, makes the English plant a sub-species—(*anglicum*).

Cnicus pratensis × *palustris*. A fairly good example of this hybrid, growing with the parents (*C. pratensis* ascendant), occurred in Max Bog, Winscombe, S.; *H. S. Thompson*.

Hieracium aurantiacum L. Railway bank, Blagdon, S.; *Miss Roper*.

Campanula Trachelium L. In the summer of 1890 I planted a root of the Nettle-leaved Bell-flower in a garden then being laid out for the first time. This plant seeded and reproduced itself plentifully in following years without attention, its descendants being partial to crevices among the stones of a small rockery and similar sterile situations. No variation was observed until 1921, when a single specimen produced pure white flowers and continued to do so in 1922. The subject of albinism and of colour-variation in general is of much interest, but attempts at explanation meet with decided difficulty. We know that white-flowered sports are frequent in some genera normally possessing blue, red or purplish flowers, and that these variations are permanent in long continued cultivation. Other groups, however, are but little affected in this way; but all flowers, whatever their tint, seem to vary most readily to white. It is known also that the colouring matter of most blue, red or purplish flowers is dissolved in the cell-sap, while a few only have chromoplastids in addition. White flowers have colourless sap and plastids. Still, little or nothing has been made out respecting the initial cause of such a change as happened to my Campanula after 31 years of stability. One understands that there has been a 'mutation,' but how and why? Biologists have lately owned that they are compelled to accept a theory of the origin of species by mutations so large that a Linnean species may arise by a single step, or at most by a few successive steps, and certainly several apparent instances of such an origin are on record. It is surmised that by the occurrence of one such mutation every fifty years or so the whole world's flora could have been obtained. Compared with these vast speculations the mere change of colour in a flower may seem trivial indeed, yet one theory will probably apply to all alike.

Linaria spuria Mill. Excellent examples of peloria in this plant were detected by Mr. Gibbons in a Horfield allotment. Similar conditions have been observed in cornfields near Bath. See *Fl. Brist.*

Veronica scutellata L. Left bank of the Chew at Pensford, S.; *F. Samson.*

V. agrestis L. This Speedwell cannot be regarded as very common in cultivations about Bristol. Latterly, however, it has been abundant as a weed in Leigh Woods gardens, and consequently has attracted some special attention in regard to the difficulty that is occasionally found in separating it, at least in the dried state, from the closely allied *V. Buxbaumii.* When flowering there can be, of course, no hesitation in the matter, the corolla of *agrestis* being relatively small and pale with the lower lobe always white. But these corollas invariably fall directly the plant is gathered, and it is in their absence that doubt arises due to a lack of precision by British authors in describing the other parts of the plant, in particular the relative length of peduncles to leaves, and the sepals. Babington says: "Leaves usually exceeding the peduncles, . . . sepals oval." And Hooker: "Leaves about as long as the peduncles." And Syme: "Ped. as long as or shorter than the leaves." I have never seen a specimen in which *some* peduncles were not longer than the leaves by as much as a third. And the sepals of *agrestis* are in fact *ovate,* subacute with blunt tips. Fries describes them as *enerviis,* but they really have three nerves or ribs, as noticed by Hooker and by Leighton. As the leaves of both species practically correspond it is of some importance, to a beginner at any rate, that such characters as can be observed in the dried plant should be accurately stated. And I note that this is well done in the *Flore de France* of Grenier et Godron.

Littorella uniflora Asch. Abundant on the margin of the Yeo Reservoir, Blagdon, S.; *H. J. Gibbons.*

[1]*Amaranthus retroflexus* L. I have only lately become aware that some of the plants thus labelled from Bristol waste heaps and garden ground belong to another species, viz., *A. chlorostachys* Willd. On reference to Continental books this is found to possess well-defined differences in the perianth and inflorescence, and it appears to be at least as frequent as *A. retroflexus.* I have come across an excellent key to the Amaranths of Western Europe in the *Boletim da Sociedade Broteriana,* Coimbra; now in the B.N.S. Library.

Chenopodium glaucum L. Casual at Ashton Gate, Bristol; *Miss Roper.*

Salicornia dolichostachya × *herbacea.* Mud-flat below Portbury. Confirmed by Dr. Salisbury; *H. S. Thompson.* This discovery is of interest as the hybrid had only been met with previously at Hayling Island.

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(1) An alien genus, but inserted here as it has a place in the *London Catalogue of British Plants.*

Euphorbia platyphyllos L. A fair quantity sprung up in an allotment at Horfield, G. ; *H. J. Gibbons.*

Juncus tenuis Willd. This introduction continues to spread in the district. It has been recognised by two observers between Nailsea and Tickenham, S.

J. compressus Jacq. By the pumping station below New Passage, G. ; *H. J. Gibbons.*

Typha angustifolia L. On the margin of the Yeo Reservoir, Blagdon, S. ; *Miss Roper.* The first authentic occurrence of the species in our area. A stranger, observing it growing side by side with common paludal species might not easily be persuaded that it could not be a native there. But before the lake was formed by damming the Yeo Valley the spot was a piece of pasture well removed above the stream. This *Typha* and the *Littorella* that accompanies it were therefore in all probability introduced on the feet of aquatic birds or by winds, and possibly from a considerable distance. Although there can be no doubt as to the species, the Blagdon plant is not the typical form we are familiar with in the Norfolk Broads and elsewhere with a long cylindrical pencil-like inflorescence, but its spike is comparatively short and somewhat ovoid in outline. *T. angustifolia* has been found to vary in several respects in other localities, and the peculiarity above mentioned is doubtless unessential.

Potamogeton Drucei Fryer. Since this pondweed was first noticed in the Avon near Bath in 1916, it has greatly increased, the patches of floating leaves being now conspicuous on the slowly moving surface of the river. Until this summer no trace of flower or fruit had been observed in the locality, but on raking out a quantity near the Midland Station at the end of August I found that about one stem in twenty had produced a small peduncle —2 to 2½″—bearing a tiny spike of abortive flowers. Specimens from the Berkshire Loddon cultivated by Mr. Fryer in Cambridgeshire ultimately bore 4-inch peduncles with flower-spikes of the same length ; and in view of distinct characters presented by the fruit and stolons, unlike those of any known pondweed, Fryer abandoned the impression that the plant was a hybrid and gave it rank as a good species. Mr. Arthur Bennett, our chief authority on the genus, writing some years ago on another supposed hybrid, says : " Fruit must be patiently waited for ; that it will come may be fairly considered as a safe suggestion. In one case in the United States fruit was procured thirty years after the species had been first discovered ; and in the case of Smith's *P. lanceolatus* an interval of eighty years occurred before a ripe fruit was seen." We are thus encouraged to believe that sooner or later this Avon

P. Drucei, which possibly travelled to Bath from the Loddon by way of the Thames and the connecting Kennet and Avon Canal, will shew us as good fruit as the plant has done in cultivation.

Gastridium lendigerum Gaud. On the golf-links at Henbury, G. ; *Mrs. Sandwith.*

Lolium perenne L. Varying curiously with a forked spike at Ashley Hill ; *C. Alden.*

Chara contraria Kuetz. Rhine below Clapton-in-Gordano, S. ; *Mrs. Sandwith.* A critical species, not easy to be sure of, but Canon Bullock-Webster agrees to the determination of this gathering.

Tolypella glomerata Leonh. Rhine on Clapton Moor, S. ; *Mrs. Sandwith.* Rhine near Portbury, S. ; *Prof. Darbishire.*

ALIENS. *Capnoides cava* Moench. (*Corydalis tuberosa* DC.). Naturalised in a wood at Ston Easton, S. ; *Mrs. Thatcher. Lavatera punctata* All. On a tip in Cranbrook Road, Redland ; *C. Alden. Astragalus odoratus* Lam. Several patches in a small area by the Avon below Bath, fruiting very sparingly. Specimens studied by Messrs. Ellman and Emile Jahandiez were identified as this Eastern species. It has occurred casually at Marseilles, and Arcangeli mentions one locality in Italy. *Coreopsis tinctoria* Nutt. By Avomnouth Dock ; *Miss Roper. Polygonum cognatum* Meisn. var. *alpestre,* C. A. Meyer. Waste ground, Cranbrook Road, Redland ; *H. S. Thompson. Ficus Carica* L. Several strong bushes on the right bank of the Avon (tow-path), near the Midland Station. Bath.

Some Recent Exposures of the Lias (Sinemurian and Hettangian) and Rhætic about Keynsham.

By J. W. Tutcher.

I.—INTRODUCTION.

Just twenty years ago a paper entitled "The Lias of the neighbourhood of Keynsham," * was published in the Proceedings of this Society. An investigation of recent exposures of the rocks in the area cited makes it possible to augment, and in some respects amend, the information given before these newer sections were available. Most of the exposures described in the earlier paper were quarries which have since suffered the common fate of small limestone workings. Many of them are now derelict, some quite obliterated, the sites they occupied reverting to agricultural uses. The principal sections to be described in this paper are even more transitory; they have been revealed by excavations for constructional purposes and have already passed from observation. These exposures, taken together, disclose a more complete view of the local Sinemurian and Hettangian strata than any yet recorded. Therefore it appears desirable the details obtained from them should be noted in the 'Proceedings' of this Society.

A summary of the geological structure of the Keynsham area is given in the 1903 paper (p. 3, et. seq.). This need not be repeated here beyond stating that crustal movements in the area have resulted in numerous folds and faults affecting the secondary rocks. The Bitton great fault, with a downthrow to the south of about 200 feet, lies just north of Keynsham. This fault throws down the Upper Lias so as to rest against the Rhætic, but many uncharted faults of smaller dimensions occur in the area; the direction of some of these is parallel, others transverse, to the major fault.

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* Proceed. Brist. Nat. Soc., vol x. (1903), pp. 1—55. This will be referred to as the 1903 paper.

II.—THE FAUNAL SEQUENCE.

During the last decade considerable attention has been directed to the ammonite sequence in the Lias deposits of this country, and numerous terms have been suggested to indicate sub-divisions of the strata. Much detailed work remains to be done before an agreed system of Liassic zoning, applicable to all areas, can be evolved.

The purpose of this paper will be served by reproducing the zonal terms suggested by the writer in 1918.† These terms at least represent the observed faunal sequence in the area under review.

ZONES OF THE LOWER LIAS (LOWER PART).

Ages.	Zonal terms.	Name of Index fossil.
Sinemurian.	*obtusum.*	*Asteroceras obtusum* (J. Sow.)
	birchi.	*Microderoceras birchi* (J. Sow.)
	turneri.	*Arietites turneri* (J. de C. Sow.)
	sauzeanum.	*Agassiceras sauzeanum* (d'Orb.)
	scipionianum.	*Ætomoceras scipionianum* (d'Orb.)
	gmuendense.	*Coroniceras gmuendense* (Oppel)
	bucklandi.	*Coroniceras bucklandi* (J. Sow.)
	rotiforme.	*Coroniceras rotiforme* (J. Sow.)
	conybeari.	*Vermiceras conybeari* (J. Sow.)
Hettangian.	*angulata.*	*Schlothemia angulata* (Schlot.)
	liasicus.	*Alsatites liasicus* (d'Orb.)
	[*megastoma.*	*Waehneroceras megastoma* (Waehner)] [1]
	johnstoni.	*Caloceras johnstoni* (J. de C. Sow.)
	planorbis.	*Psiloceras planorbis* (J. de C. Sow.)
	Ostrea.	*Ostrea liassica,* Strickland, and its mutations
	tatei.	*Pleuromya tatei,* Richardson and Tutcher
	langportensis (White Lias).	*Volsella* (*Modiola*) *langportensis,* Richardson and Tutcher

The two upper zones do not appear in the original table, but are included here as reference to them will be necessary—*obtusum, birchi,* and *turneri* must, however, be regarded as provisional terms since the deposits they indicate admit of considerable sub-division. Moreover, the relative positions of *birchi* and *turneri* given in the above table are not always accepted for other areas. Locally these upper beds are too thin and incomplete for detailed zoning, they are much better developed in Dorset, where Dr. Lang and

† Quart. Journ. Geol. Soc., vol. lxxiii (1918), p. 279.

1. The evidence for deposit of *megastoma* date at Keynsham is inconclusive.

Dr. Spath have recently worked out the ammonite sequence. In this connection the publication of their paper on "The Shales-with-Beef," read before the Geological Society in January last, is awaited with interest.

There is no evidence in the Keynsham area for the *oxynotum* zone which usually succeeds *obtusum.* The references to *oxynotum* in the 1903 paper were founded on the misidentification of a badly preserved fragment of an Ammonite.

III.—STRATIGRAPHY.

1. Section at Saltford Mead.

The latest deposits of Sinemurian age observed in this area were seen in excavations for the septic tanks of the Bath sewage works, two miles east of Keynsham, and near the "Jolly Sailor Inn" at Saltford Mead.

The excavations commenced below the 50′ contour and penetrated Blue Lias clays and limestones down to the *gmuendensis* subzone. At 15—20 feet from the base nodules of limestone were obtained containing specimens of *Asteroceras obtusum, Microderoceras birchi,* and *Arietites turneri.* The preservation of Beds indicated by these Ammonites is due to an uncharted fault with a downthrow to the north of about 50 feet, and their presence was not suspected since a mural face of *angulata* and *bucklandi* limestone borders the lane from Saltford nearly to the site of the excavations.

These higher beds of Sinemurian age are very rarely exposed in this district. It is therefore most unfortunate that the greater part of the section had been bricked in before the writer was aware of its existence. Hence the following account of the relative position and contents of the beds is mainly dependant on information supplied by an intelligent Clerk of Works and an examination of the excavated material :—

	Feet.
River gravel alluvium and clay	20
Septarian nodules, extensively veined with calcite. *Asteroceras obtusum ; Zipheroceras planicosta.* Nodules of similar lithic character, *Microderoceras birchi.* Nodules with fewer calcite veins, *Arietites turneri.* Calcareous concretions, non-septarian, waterworn, *Arietites turneri ; Arietites* sp.	6
Blue clay with thin layer of pyritized fossils. *Arietites* sp.	
Blue Clay. *Nautilus striatus.*	
Blue Clay, with a 5-inch Bed of blue limestone weathering rusty brown, full of *Arinoceras* cf. *bodleyi ; Arnioceras* spp.	

	Feet.
Blue Clay, crushed specimens of *Rhynchonella semicostati*, Vaughan and Tutcher.*	
Blue Clay. *Paracoroniceras gmuendense* at the base.	14

As already stated the nodules in this section were not observed in situ. Their relative positions are suggested mainly by differences in the matrices, supported by statements of the workmen. There is little doubt, of course, that *obtusum* occupies the uppermost position. The nodules containing *birchi* are similar in lithic character, while those with *turneri* are less septarian. The condition of the fossils in all these is similar, the shell is preserved, and is of a whitish chalky nature. The concretions containing *turneri*, placed below these, are obviously different, they are non-septarian, and the fossils in them are cleanly cut casts.

The *Arnioceras* limestone is similar in character and contents to a widely distributed bed above the *Agassiceras* zone in this district.

Well preserved fragments of *Paracoroniceras* were obtained from the floor of the excavation, about 10 feet above ordnance datum.

2. Keeling's Quarry, Keynsham.

The next section to be described is situated within the angle formed by the junction of the Bath and Burnet Roads at Keynsham. This quarry, within the last year or two, has been considerably enlarged ; it now exhibits the finest continuous section of Lower Lias to be seen in the district. The south face is excavated to a depth of 33 feet in deposits of Lower Sinemurian and Upper Hettangian ages. But it is to the upper 18 feet (Sinemurian) that attention is here directed. All the subzones from *conybeari* to *sauzeanum* are represented. The upper portion consists of clays and shales with thin bands of marl containing many ill-preserved fossils, especially *Arnioceras* and *Agassiceras*. Below this, hard blue limestones, with numerous species of large Arietids, predominate. The lowest bed of the Sinemurian is a conspicuous thick limestone which is generally studded with a small brachiopod, *Rhynchonella calcicosta*, Dav. non-Quenstedt.‡ For this reason the bed is referred to as the *calcicosta* limestone. The *calcicosta* limestone marks the division between the Sinemurian and Hettangian, no Arietids are found below it, but *Schlotheimia*, mainly of the *charmassei* type, sometimes occur a little above it. *S. angulata* is, however, confined to the Upper Hettangian.

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* 1903 paper, p. 53.

‡ A series of similar Rhynchonellids usually referred to *R. calcicosta* occurs throughout the *angulata* zone. Davidson (Mon. vol. iv., pl. xxviii., fig. 24-32) includes different shells, from various horizons, under this name. Buckman (Pal. Indica, p. 30, pl. xix., fig. 11-12) renamed Davidson's fig. 27 *Calcirhynchia calcaria*. Probably our shell should be referred to that species

	Ft.	Ins.
sauzeanum.		
Clay with 4 bands of pale calcareous marl, each about 4 inches in thickness. The fossils occur chiefly in the beds of marl. *Agassiceras* cf. *sauzeanum* (D'Orbigny); *A. spinaries* (Quenst.); *Agassiceras* sp. nov.; *Arnioceras cuneforme,* Hyatt; *A.* cf. *ceratitoides* (Quenst.); *Arnioceras* spp.; *Belemnites infundibulum,* Phillips; *Pecten* (*Chlamys*) *textorius* (Schlot.); *Rhynchonella semicostati,* Vaughan.	5	4
scipionianum.		
Blue limestone with occasional phosphatic nodules at the base. *Ætomoceras scipionianum* (D'Orbigny); *Arnioceras geometricum* (Oppel); *Pecten textorius* (Schlot); *Terebratula ovatissima,* Quenst.	1	3
Paper Shale with thin limestone bands at the top. *Ætomoceras* sp. indet.; *Arnioceras* sp.; *Avicula* cf. *inæquivalvis,* Sow.; *Pecten hehli,* D'Orb.; *Anomia pellucida,* Terq.	1	0
Sandy Shale.		4
gmuendense.		
Blue gritty limestone, with badly preserved Ammonites. *Paracoroniceras* cf. *trigonatum* (Hyatt).		4
Four beds of blue limestone with shale partings. *Paracoroniceras gmuendense* (Oppel); *Epammonites compressaries* (Reynès); *E.* cf. *latisulcatus* (Quenst.); *Megarietites* cf. *meridionalis* (Reynes); *Arnioceras* sp.; *Plagiostoma gigantea,* Sow. (small form); *Rhynchonella* cf. *triplicata juvensis* (Quenst.)	3	10
bucklandi.		
Three beds of blue limestone with shale partings. *Coroniceras* cf. *cæsar* (Reynès); *Coroniceras bucklandi,* (Sow.); *Schlotheimia* cf. *charmassei* (D'Orb.)	2	6
rotiforme.		
Limestone and Shale. *Coroniceras rotiforme* (J. de C. Sowerby); *C. rotator* (Reynès); *Nautilus intermedius,* Sow.	1	10
conybeari.		
Shale. *Schlotheimia* cf. *charmassei* (D'Orb.); *Plagiostoma gigantea,* Sow. (large specimens).		6
Blue Limestone. (The *calcicosta* Limestone). *Vermiceras conybeari* (Sow.); *Vermiceras* sp.; *Schlotheimia* cf. *greenhoughi* (Sow.); *Rhynchonella calcicosta,* Dav. (very common).	1	4

In this quarry there are 13 feet of limestone and clay below the *calcicosta* limestone. These (Hettangian) deposits will be described from the following sections.

3. Sections at Keynsham Hams.

The sections next to be described occupy the site recently acquired by Messrs. J. S. Fry & Sons at Keynsham Hams. I am indebted to this firm for permission to examine the excavations as work on them proceeded. The site is bounded on three sides by the River Avon, and some of the area is covered by alluvial deposits. A tongue-shaped tract of high ground projects into this area and upon this, above the 50′ contour, a road has been constructed and a factory erected. A railway siding cuts into the high ground on the eastern side, and the section thus disclosed exhibits 23 feet of Lower Sinemurian and Upper Hettangian deposits, affected by sharp folds striking north and south (fig. 1). East of the factory a deep excavation for a power-house shows 26 feet of lower beds (*liasicus* and *johnstoni* zones), whilst a trench at the river side, cut for foundations of a wharf, penetrates still lower beds of Lias down to the Cotham marble. A well west of the factory cuts through Lower Rhætic and the underlying Keuper to a depth of 36 feet.

So complete a view of the lowest beds of the Lias is rarely obtained at one place in this district. The *Alsatites liasicus* zone, especially well seen here, consists of clays with subordinate bands of limestone ; these being of little commercial value are not exposed in the quarries. The beds are much thicker than was suspected when the 1903 paper was written, the clay bands, there referred to the base of *angulata*, commence a series of such beds shown here to be nearly 30 feet in thickness.

Two sharp anticlines are visible on the west side of the railway siding, but, owing to the small angle the line of strike makes with the line of section, only one of these can be traced to the opposite bank, the other passes outside the boundary of the site. An excavation immediately north of the factory traverses these folds and exhibits much distortion of strata in the *liasicus* zone, the power-house section just east of the factory being parallel with the folding shows an orderly arrangement of the same beds.

KEYNSHAM HAMS.

A.—The Railway Siding.

Sinemurian.

	Ft.	Ins.
bucklandi.		
Limestone, much shattered, fragments of *Coroniceras bucklandi* (Sow.)		10
Clay. *Pecten* cf. *hehli*, d'Orb.		2
rotiforme.		

WEST BANK of RAILWAY SIDING at KEYNSHAM HAMS.

Depth of Section 21 feet. The Arrow indicates position of the "CALCICOSTA Limestone."

Fig. 1.

	Ft.	Ins.
Limestone. *Coroniceras rotator* (Reynes); *Nautilus striatus*, Sow.; *Rhynhconella juvensis* (Quenst.)		9
Clay.		5
Limestone. *Coroniceras rotator* (Reynès)		7
Clay.		2
Limestone. *Schlotheimia* cf. *charmassei* (d'Orb.), large specimens.		6
conybeari.		
Clay. *Schlotheimia* cf. *charmassei* (d'Orb.), small specimens; *S. posttaurina*, Wähner; *Coroniceras* cf. *cordieri* (Canavari) (Wähner); *Vermiceras* cf. *conybeari* (Sow.); *Pleurotomaria* sp.; *Gryphaea* cf. *incurva*, Sow.		5
Limestone, with many specimens of *Rhynchonella calcicosta*, Dav. (the *calcicosta* limestone).	1	6
HETTANGIAN.		
angulata.		
Clay.		1
Limestone. *Schlotheimia angulata* (Schlot.); *S. extranodosa* (Wähner); *Rhynchonella calcicosta*, Dav.		8
Clay.		1
Limestone. *Lima hettangiensis*, Terq.		3
Clay.		2
Limestone. *Schlotheimia* sp.		3
Clay. *Schlotheimia angulata* (Schlot.)		2
Limestone. *Rhynchonella calcicosta*, Dav.		9
Limestone, with clay partings, small specimens of *Gryphæa*.		9
Clay.		6
Limestones, nodular, with irregular clay partings. *Schlotheimia* spp.; *Lima gigantea*, Sow.; *L. hettangiensis*, Terq.; *Gresslya galathea*, Ag.	4	6
liasicus.		
Limestone. *Modiola hillanoides*, Chap. and Dew.		6
Clay. *Alsatites liasicus* (d'Orb.); *Ornithella sarthacensis* (d'Orb.)	1	4
Limestone. *Nautilus intermedius*, Sow.		7
Nodular limestones, with clay partings. *Alsatites liasicus* (d'Orb.); *Ornithella sarthacensis* (d'Orb.); *Lima succincta* (Schlot.)	2	6
Clay. *Alsatites* sp.; *Lima succincta* (Schlot.)	1	6
Limestone. *Schlotheimia* sp.; *Modiola laevis*, Sow.		7
Clay.		2
Limestone. *Lima dunravenensis*, Tawney.		3
Clay. *Ostrea irregularis*, Mü.		3
Limestone. *Nautilus intermedius*, Sow.		5
Clay.		2
Limestone. *Cardinia ovalis*, Stutch.		3

B.—Power-house and Wharf Sections.

		Ft.	Ins.
liasicus.			
Clay.		2	0
Limestone. *Alsatites liasicus* (d'Orb.)			4
Clay. *Ornithella sarthacensis* (d'Orb.)			4
Limestone. *Astarte consobrina*, Chap. and Dew.			6
Clay		1	2
Limestone			5
Clay		2	0
Limestone			6
Clay	*Waehneroceras curviornatum* (Waehner) ?;	1	6
Limestone	*Psiloceras crebricinctum*, Waehner ?;		9
Clay	*Astarte consobrina ;*	1	6
Limestone	*Lima hettangiensis ;*		4
Clay	Many specimens of *Lima gigantea,*	6	0
Limestone	but no *Gryphæa.*		6
Clay		2	6
Limestone			5
Clay			8
johnstoni.			
Limestone.			4
Clay. *Lima dunravenensis,* Tawney.			4
Limestone in 2 bands with clay partings. *Pleuromya liasinus* (Schubl.)			9
Limestone. *Caloceras intermedium* (Portlock) ; *Pholadomya fraasi,* Oppel.			10
Clay.			4
Limestone. *Caloceras intermedium* (Port.)			7
Clay.			4
planorbis.			
Limestone. *Psiloceras sampsoni* (Portlock) ; *Lima* cf. *gigantea,* small specimens.			6
Ostrea.			
Thin limestones with clay partings. *Ostrea liassica,* Strick., common.		2	0
tatei.			
Thin limestones. *Pleuromya tatei,* R. & T. ; *Macrodon hettangiensis,* Terq. ; *Protocardium phillipianum* (Dunk.)		2	0
langportensis.			
Light grey, compact limestone (sun-bed)		1	4
Several beds of light grey, somewhat marly, limestone with thin clay partings. *Modiola langportensis,* R. & T. ; *Pleuromya langportensis,* R. & T. ; *Protocardium phillipianum* (Dunk.) ; *Pecten pollux,* d'Orb.		4	8
Clay.			4
Cotham Marble			

It is possible that a few of the upper beds seen in the factory foundations repeat the lowest beds in the railway siding, or there may be a small gap between them. The error, if any, is very small, *Alsatites* occurs near the top of the one and in the base of the other. The lithological differences suggest that all the beds in the Power-house section are additional to those in the siding.

The paucity of fauna recorded from the lower part of the *Alsatites liasicus* zone is probably illusory. The difficulty of collecting from a vertical face of newly cut rock is obvious ; moreover, the section was available for only a short time, and the limestones were broken up for concrete directly they were extracted, leaving very little excavated material available for examination. One fragmentary Ammonite was obtained, of which Mr. Buckman says : " Possibly a *Waehneroceras* (cf. *W. curviornatum*, Waehner)." This is interesting since it suggests some deposit of the *megastoma* zone, hitherto believed to be absent in this district. More research in this direction is needed, as the small amount of evidence yet available is inconclusive.

The sequence from *liasicus* to *planorbis* was observed without a break, but below this the information obtained was dependant mainly on excavated material taken from the wharf trench below the river level, consequently the measurements given of these lowest beds are only approximate.

It will be noted that the *planorbis* zone, indicated by a profusion of *Psiloceras sampsoni*, is confined to one bed 6 inches thick. This is the case generally in the Bristol-Bath district. Its insignificance has led to statements that the *planorbis* zone is absent ; it is, however, usually present, but often overlooked.

C.—The Well Section.

About 450 yards west of the factory.

	Ft.	Ins.
Rhætic.		
Yellow clay and Lower Rhætic shale.	12	
Firm, black, non-laminated shale.	2	
Thin pyritic band, with Fish teeth.		1
Keuper.		
Tea-green Marl.	12	0
Red Marl.	10	0

Water was obtained in considerable quantity at 36 feet from the surface after blasting a 'hard rock.' In the absence of a sample of this rock the writer is unable to determine whether the Pennant Grit was reached, in which case the Keuper is unusually thin, or whether this bottom bed is a sandstone in the Keuper series.

It has already been stated that numerous small folds and faults affect the secondary deposits of the Keynsham area. There is reason to suppose the existence of a fault, striking north and south, on each side of this contorted tract at the Hams. After allowing for the effect of folding it is difficult otherwise to connect the beds of this elevated tract with those to the east and west. The general dip is about 3° to the north-west, but, in a quarry 500 yards east of the siding, and outside the boundary of the Hams site, the same beds are seen at a much lower level dipping east. Then the Well west of the factory commences in Lower Rhætic about 40 feet above ordnance datum, whilst at the Wharf the Lower Rhætic is below 10.O.D. A bifurcating fault, striking S.S.W., is charted on the one-inch Geological Survey map No. 35, if the limbs of this fault, which are traced to the north bank of the river, be extended across it into the Hams the conditions obtaining there would be explained. This view is expressed in the generalized section, (fig. 2), where each fault is represented by a downthrow of about 30 feet to the east.

An item of geological interest, although not germane to the subject of this paper, may be recorded here. In an excavation west of the factory, at about 38 feet above the present mean level of the river, a bed of gravel 4 or 5 feet thick was disclosed. One fragment of Oolitic rock, found by Mr. Usher, of Bitton, contained two species of Callovian Ammonites, *Proplanulites arciruga*, Tornq., and *P. ordaleus*, Buckman. The nearest place from which Callovian fossils have been recorded is in the neighbourhood of Trowbridge, 14 miles S.E. of Keynsham. Probably these pebbles were derived from deposits further west, which have been denuded since the river flowed at the higher level.

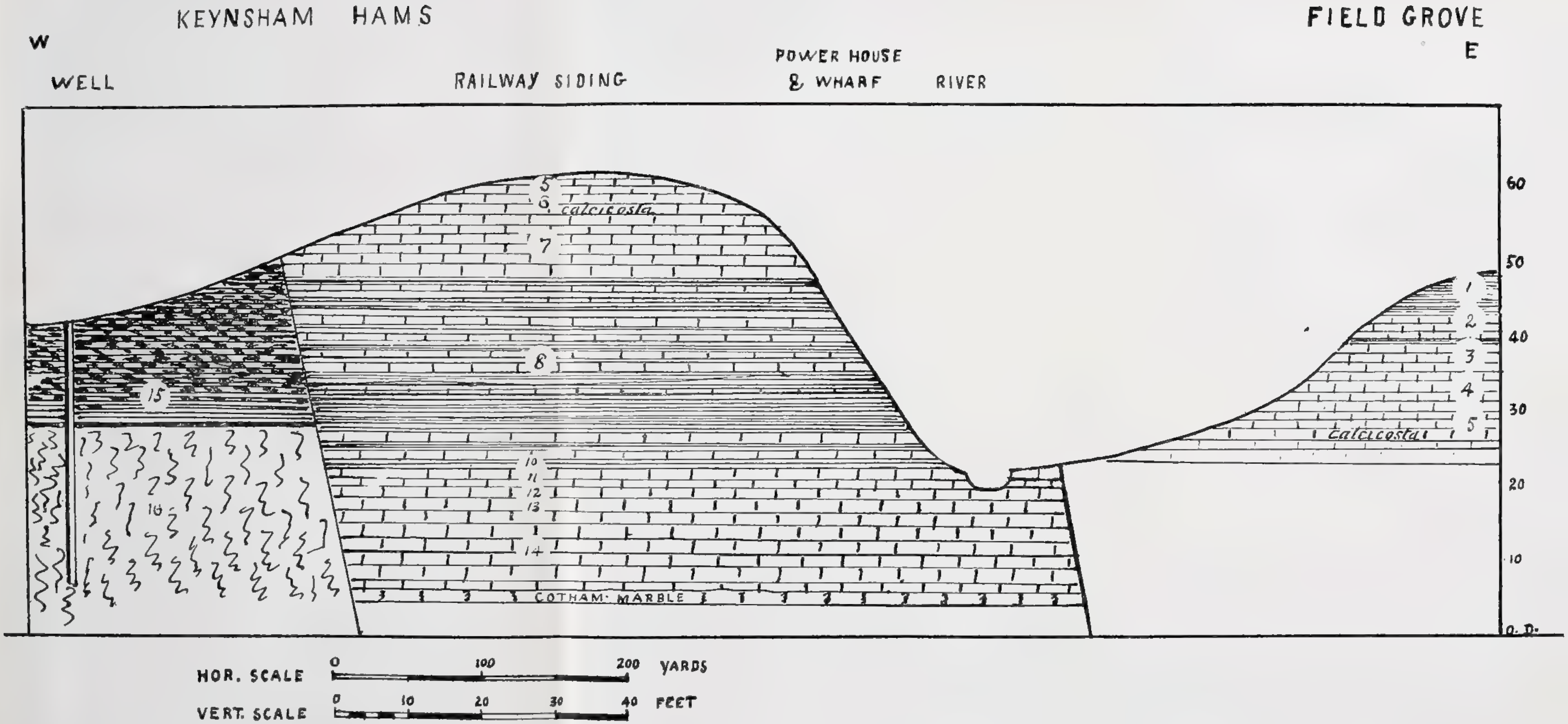
4. Rhætic Section at Bitton.

The section here recorded is taken from a well on the premises of Mr. Whyatt, at Ryedown Lane, four furlongs due east of Bitton Railway Station. The well is situated just north of the Bitton great fault. It is on the same geographical level as the Upper Lias sand pits at Jay Hill, about 300 yards to the south-east ; both are above the 200′ contour.

The excavation for the well commences in the White Lias, and is carried through the Upper and Lower Rhætic down to a well-marked horizon, viz., the hard barren shale, just below which the principal Rhætic Bone-bed, when present, usually occurs.*

* Proceed. Brist. Nat. Soc., vol. xi. (1908), p. 18, et. seq.

Fig.



GENERALIZED SECTION AT KEYNSHAM HAMS.

1. *sauzeanum.*
2. *scipionianum.*
3. *gmuendense.*
4. *bucklandi.*
5. *rotiforme.*
6. *conybeari.*
7. *angulata.*
8. *liasicus.*
9. *megastoma.* *
10. *johnstoni.*
11. *planorbis.*
12. *Ostrea.*
13. *tatei.*
14. *langportensis.*
15. RHÆTIC.
16. TRIAS.

* *Possibly absent at Keynsham.*

Fig. 2.

THE WELL IN MR. WHYATT'S GARDEN.

		Ft.	Ins.
	Soil and rubble.	2	0
White Lias (*langportensis*)	Creamy Limestone (Sun-bed).	1	4
	Rubbly White Lias. *Modiola langportensis,* R. & T. ; *Protocardium phillipianum* (Dunk.) ; *Dimyodon intusstriata* (Emm.) ; *Pleuromya langportensis,* R. & T.	4	0
	Shale.		6
Upper Rhætic	Cotham Marble, in typical form.		6
	Grey marl, arenaceous in the lower part.	3	0
	Grey marly limestone. Ostracods.	1	0
	Grey marl.	2	0
	Grey marly Limestone. Ostracods ; *Estheria, Naiadites.*		10
Lower Rhætic	Black laminated shale, full of shells at several levels. *Avicula contorta ; Myophoria postera ; Pecten valoniensis ; Cardium cloacinum ; Schizodus* spp.	7	0
	Hard pyritic limestone.		3
	Hard, black, imperfectly laminated shale. No fossils.	1	6
	Thin limestone with much pyrites. Fish scales and small teeth.		1
		24	0

In conclusion the writer desires to acknowledge his great indebtedness to Mr. S. Buckman, F.G.S., for assistance in naming the Ammonites ; to Mr. H. F. Barke, F.I.C., for help in the field on many occasions ; and to Mr. T. R. Fry for submitting many important specimens. My thanks are also due to Messrs. J. S. Fry & Sons, and members of the staff, who have afforded me every facility to examine the important sections at Keynsham Hams, which have added much to our knowledge of local Hettangian deposits.

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